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TETRIX TUERKI (ORTHOPTERA, TETRIGIDAE): DISTRIBUTION IN UKRAINE, ECOLOGICAL CHARACTERISTIC AND FEATURES OF BIOLOGY

T. I. Pushkar

Schmalhausen Institute of Zoology, NAS of Ukraine,
Bogdan Chmielnicky str., 15, Kyiv, 01601 Ukraine
E-mail: taras@izan.kiev.ua

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***Tetrix tuerki* (Orthoptera, Tetrigidae): распространение в Украине, экологическая характеристика и особенности биологии. Пушкар Т. И.** — Подтверждена находка *Tetrix tuerki* (Krauss, 1876) на территории Украинских Карпат, в Прикарпатье и Закарпатье, где он встречается в долинах горных рек. *T. tuerki* представлен тремя морфологическими формами: короткокрылой, среднекрылой и длиннокрылой. Зимуют имаго короткокрылой и среднекрылой форм, а также личинки последних возрастов; длиннокрылые особи появляются в июне из перезимовавших личинок. Личинки, превращающиеся в имаго в год своего появления, становятся короткокрылыми и среднекрылыми особями. Биотопическая приуроченность изменяется на протяжении сезона и специфична для разных морфологических форм. Весной *T. tuerki* встречается на границе песчаных и песчано-галечниковых береговых наносов и пойменной террасы, покрытой травянистой растительностью (короткокрылая и среднекрылая формы), летом — на наносных косах и островках, часто далеко от берега (длиннокрылые особи). В среднем течении горных рек, где наносы хорошо развиты, присутствуют все морфологические формы; в верхнем течении, где наносы преимущественно галечниковые, и в нижнем, где берега приобретают равнинный характер, встречаются только короткокрылые и среднекрылые особи. Длина тела особей максимальна в среднем течении и уменьшается в верхнем и нижнем течении горных рек. Вибрационные сигналы *T. tuerki* описаны впервые. Приведены осциллограммы вибрационных сигналов.

Ключевые слова: Orthoptera, Tetrigidae, *Tetrix tuerki*, распространение, Украинские Карпаты, прибрежные биотопы горных рек, фенология, вибрационные сигналы.

***Tetrix tuerki* (Orthoptera, Tetrigidae): Distribution in Ukraine, Ecological Characteristic and Features of Biology. Pushkar T. I.** — The presence of *Tetrix tuerki* (Krauss, 1876) in the Ukrainian Carpathian Mountains and Transcarpathian Region nowadays is confirmed. Three different morphological forms of *T. tuerki* are distinguished based on the wings and prothorax lengths: brachypterous, mesopterous and macropterous forms. Only two forms of adults (mesopterous and brachypterous) and the larvae of middle and the last instars hibernate. Adults of macropterous individuals of *T. tuerki* appear in June, developing from the hibernated larvae. Some larvae of *T. tuerki* are emerged from eggs and become the adults at the same year, transforming mesopterous and brachypterous forms. In spring *T. tuerki* (brachypterous and mesopterous individuals) lives on sandy-pebble alluvion of mountain river coasts, but in summer it (macropterous individuals) prefers alluvions near the middle part of the river far from its coasts. All three morphological forms of *T. tuerki* inhabit the middle flows of mountain rivers and the foothills outside a mountain system; brachypterous and mesopterous individuals are widespread in the upper reaches and in the lower flows of mountain rivers where alluvions are rare. Body length of specimens of *T. tuerki*, inhabiting upper and lower flows mountain rivers are smaller then in other river sides. Vibratory signals of *T. tuerki* are described for the first time and the oscillograms of the vibratory signals are provided.

Key words: Orthoptera, Tetrigidae, *Tetrix tuerki,* distribution, Ukrainian Carpathian Mountains, alluvion of mountain rivers banks, phenology, vibratory signals.

Introduction

The family Tetrigidae (Orthoptera), or pygmy locusts is a group of small orthopterous insects distributed worldwide. It includes about 1400 species belonging to 270 genera (Devriese, 2004). This family is characterized by the elongated prothorax (protuberance of prothorax), which fully covers the abdomen

dorsally and can be considered as a functional analogue of tegmina (elytra), while tegmina of Tetrigidae are reduced to the two small sclerotized plates on both sides of prothorax. The length of prothorax of Tetrigidae depends from the stage of development of hind wings (alae) and represents the major morphological parameter of individuals ability to flight. It was previously recorded that each specimen of pygmy locusts belongs to one of two morphological groups: brachypterous and macropterous forms (Bey-Bienko, 1951; Benediktov, 1998, 2002, 2005; Pushkar, 2005). At the same time Bazyluk (1958) discussed the necessity of more fractional subdivision of morphological forms of Tetrigidae.

Our research shows that three morphological forms of adults of pygmy locusts can be recognized: the brachypterous, the mesopterous and the macropterous.

The brachypterous form is characterized by weakly developed wings and short protuberance of the prothorax, which does not extends beyond the posterior point of the hind femur. The mesopterous form has better developed wings and the prothorax protuberance extended beyond the posterior point of the hind femur less than on the half of the the hind femur length. The macropterous form has fully developed wings and long protuberance of prothorax that extends beyond the posterior point of the hind femur more than on the half of its length (fig. 1). Simultaneously, the protuberance of prothorax of macropterous form can be longer or shorter than the length of wings, and macropterous individuals often can be definitely recognized based on wings length rather than from the length of prothorax protuberance.

The tetrigids, unlike the majority of other Orthoptera, have no sound communications by stridulation, and for a long time they were called "deaf-mutes". A peculiar character of pygmy locusts is the absence of tympanum on the first abdominal tergite. Capability of pygmy locusts to communicate by vibratory signals, which can be distributed through a substratum (soil or dry plant residues) was recorded (Benediktov, 1998). Currently, distinctive vibratory signals of nine species of pygmy locusts were recorded and described; among them five species are distributed in Ukraine (Benediktov, 1998, 2002, 2005).

The species of pygmy locusts present in Ukraine can be considered as eurytopic or stenotopic species, depending on the presence or absence of the preferable habitats. Preliminary results of my studies demonstrate that the species of pygmy locusts whose borders of distributional ranges lie in Ukraine (*Tetrix bipunctata* (Linnaeus, 1758), *T. undulata* (Sowerby, 1806), *Uvarovitettix depressus* (Brizout de Barnevill, 1849), *T. bolivari* Saulcy, 1901), can be considered as stenotopic species because their natural habitats are rarely represented in Ukraine. On the other hand, the Tetrigidae species widespread in Ukraine can be considered as eurytopic species because their natural habitats are present everywhere.

T. bipunctata occurs in the Carpathian Mountains to Polissya and the north of the Wood-and-Steppe zone. This species inhabits mainly wet glades with well-grown moss blanket in old fir, pine and oak forests, especially near mesotrophic and oligotrophic peat-bogs. *T. undulata* usually inhabits in environs of mesotrophic and eumesotrophic peat-bogs of Polissya and north-western part of the Wood-and-Steppe Zone. *U. depressus* is hydro-thermophilic species, distributed on the Southern Coast of the Crimea. Original observations (Pushkar, 2005) confirmed that *T. bolivari* inhabits environs of freshwater and saltish reservoirs along the coasts of the Black and Azov seas, but also reaches the central part of the Wood-and-Steppe Zone along the valleys of big rivers.

Only two species, *T. subulata* (Linnaeus, 1758) and *T. tenuicornis* (Sahlberg, 1893) are comparatively eurytopic and widespread in Ukraine, inhabiting direct environs of freshwater reservoirs, water-meadows, forests edges, but being very rare in more arid biotopes.

The main goal of my research was the explanation of the distribution of the poorly studied species *T. tuerki* (Krauss, 1876) and investigation of its biology, life cycle, ecological preferences and feeding behavior.

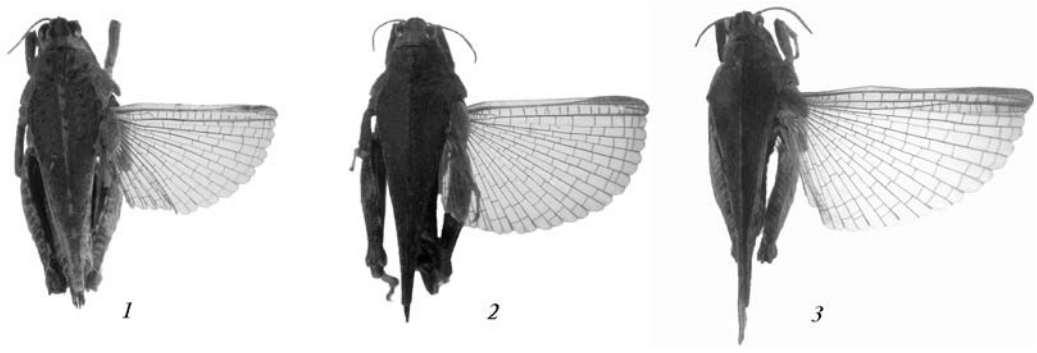

Fig. 1. Morphological forms of *T. tuerki* (♀): *1* — brachypterous form; *2* — mesopterous form; *3* — macropterous form

Рис. 1. Морфологические формы *T. tuerki* (♀): *1* — короткокрылая; *2* — среднекрылая; *3* — длиннокрылая

T. tuerki was firstly recorded from Ukraine by Lomnicki (1905); it was found on the coastal biotopes of the Bystrytsya (environs of Ivano-Frankivsk) and Prut Rivers (environs of Kolomiya in Ivano-Frankivsk Region) (fig. 2), but it was not subsequently mentioned for Ukraine (Chetyrkina, 1950; Bey-Bienko, 1951, 1964; Likovich, 1959, 1979, 1984; Harz, 1975; Podgornaya, 1983; Devriese, 1996, 2004; Heller et al., 1998; Heller, 2006).

Previous study confirmed the presence of *T. tuerki* in Ukraine only in the Carpathian Mountains (Pushkar, 2005). The present study has gained data on the easternmost border of the area of this species, particularly its nominative subspecies (fig. 2).

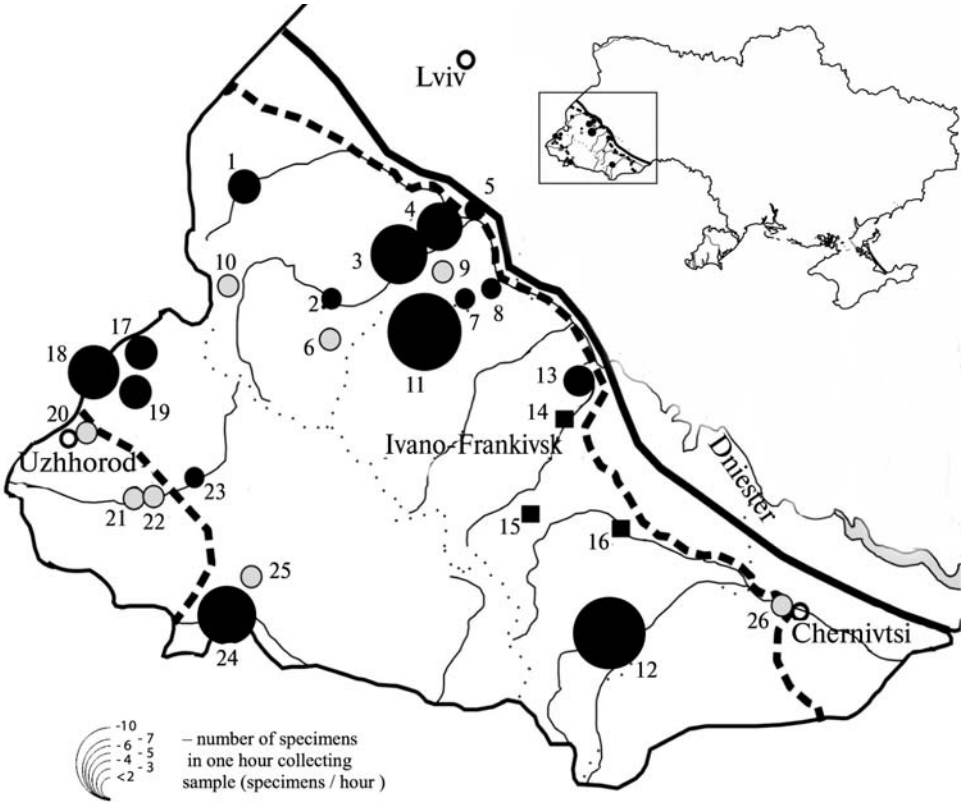

Fig. 2. Map of studied region, with the collecting localities.

Рис. 2. Карта-схема региона исследований с обозначением точек проведения сборов.

1–26 – localities of collecting samples; ● – own finds *T. tuerki;* ● – localities where *T. tuerki* wasn't found; ■ – the literature and museum data; ——— – the state boundary of Ukraine and the boundaries of Ukrainian Carpathian Mountains; – – – – the borders of a natural habitat *T. tuerki* in Ukraine

Lviv Region: 1 — flood-lands of Dniester River near city Staryi Sambir; 2 — flood-lands of Stryi River near village Verkhnie Synievydne (Skole District); 3 — flood-lands of Stryi River near city Stryi; 4 — flood-lands of Stryi River near city Zhidachiv; 5 — flood-lands of Stryi River near fusion with Dniester River, village Zalissya (Zhidachiv District); 6 — upper reaches of Opir River near city Skole; 7 — flood-lands of Svicha River, village Zhuravno (Zhidachiv District); 8 – flood-lands of Svicha River near a fusion with Dniester River near village Zhuravno (Zhidachiv District); 9 — flood-lands of Berezhnitsya River near village Oleksichi (Dashava District); 10 — the lake near village Syanki (Turka District); **Ivano-Frankivsk Region:** 11 — flood-lands of Svicha River, village Goshiv (Dolyna District); 12 — flood-lands of Chorny Cheremosh River, village Kryvorivnya (Verkhovyna District); 13 — flood-lands of Bystrytsya Nadvirnyanska River near city Ivano-Frankivsk; 14 — flood-lands of Bystrytsya Nadvirnyanska River near village Mykytyntsi (city Ivano-Frankivsk); 15 — flood-lands of Manyavka River near village Starunya (Bogorodchany District); 16 — flood-lands of Prut River near city Kolomiya; **Zakarpattya Region:** 17 — flood-lands of Uzh River, railway station Sil' (Velyke Berezne District); 18 — flood-lands of Uzh River, village Dubrynychi (Perechyn District); 19 — flood-lands of Lyutyanka River near village Dubrynychi (Perechyn District); 20 — flood-lands of Uzh River near city Uzhhorod; 21 — flood-lands of Latoritsya River near village Chinadiyovo (Mukacheve District); 22 — flood-lands of Latoritsya River, railway station «Carpathians» (Mukacheve District); 23 — flood-lands of Latoritsya River near city Svalyava; 24 — flood-lands of Tisa River near city Khust; 25 — flood-lands of Khustets River near village Nankovo (Khust District); **Chernivtsi Region:** 26 — flood-lands of Prut River near city Chernivtsi.

Material and methods

Material was collected in 21 sites of Ukraine (Lviv, Ivano-Frankivsk, Zakarpattya and Chernivtsi Regions) (see also fig. 2) during 2006–2008 (April to July). For determination of population density the specimens *T. tuerki* were collected over a certain time with a further recalculation for one hour (Pravdin et al., 1972). The specimens of *T. tuerki* were kept under the laboratory conditions (+29–30°C) in a rearing cage for a further observations on a feeding behavior and peculiarities of a life cycle.

The specimens of *T. tuerki* from Ukraine are deposited in the collection of Schmalgausen Institute of Zoology of National Academy of Sciences of Ukraine (SIZK). A comparative material from the collection of Orthoptera of Zoological Institute of Russian Academy of Science (ZISP, Saint-Petersburg, Russia) and State Natural History Museum of National Academy of Sciences of Ukraine (NSML, Lviv, Ukraine) were investigated. The photographs of syntypes of *T. tuerki*, deposited in the collection of Stuttgart State Museum of the Natural Sciences (SMNS, Germany) were examined (SysTax & DORSA, 2008).

The abbreviations of measurements (terminology follows Harz, 1975; Devriese, 1996; Storozhenko, Paik, 2007): BL_1 — length of a body on the lateral view from a frontal surface of a head to the end of protuberance of prothorax; BL_2 — length of a body on a the lateral view from a frontal surface of a head to the end of abdomen; PL — length of prothorax from an anterior edge to the end of protuberance of prothorax; PH — the maximal height of prothorax from the median carina to the lower edge of the lateral lobes of prothorax; WL — length of the hind wing (ala) from the tegmen base to the wing apex; TL — length of the visible part of tegmina on the lateral view; FL — length of the hind femur; FW — maximal width of the hind femur; VL — length of the dorsal valve of ovipositor; VW — maximum width of the dorsal valve of ovipositor; SL — length and SW — maximal width of the longest segment of antenna.

Indices: PI (prothorax index) = PL/PH; FI (hind femur index) = HL/HW; VI (dorsal ovipositor valves index) = VL/VW; SI (antenna median segment index) = SL/SW.

Most field observations on the phenology of *T. tuerki* were carried out near the Stryi River (Carpathian region) in April-July 2006–2008. Some additional quantitative data about *T. tuerki* were obtained in many other localities of Carpathian region (fig. 2).

Five larval instars in males and six in females were recorded for some pygmy locusts (*T. subulata*, *T. bipunctata, T. undulata*), occurring in Ukraine [Farrow, 1964 (cit. from: Podgornaya, 1981); Podgornaya, 1981]. According to my observations, *T. tuerki* has at least five instars. Since identification keys to larval instars of the pygmy locusts do not exist, the correct identification of the larval instars of *T. tuerki* is rather difficult. That is why we recognize below three groups of larval instars of *T. tuerki*: early instars (I–II instars), middle instars (III–IV instars) and last instars (presumably V instar).

Recording of vibratory signals of *T. tuerki* were carried out after A. A. Benediktov (1998, 2002, 2005). In the laboratory experiments the temperature fluctuated between 29–31°C. The specimens of *T. tuerki* were placed on substratum (a small cardboard plate, 75 mm X 90 mm, covered by transparent cap), and different combinations of specimens were used (single specimen of male or female, two males, two females, or male with female) in this experiment.

The cardboard plate was attached by a flexible spring to a metallic needle of piezo-electric receiver. The receiver accepted vibratory signals produced by specimens of *T. tuerki*, placed on the cardboard plate, then this signal consistently magnified by a transistor amplifier and transferred to the computer sound card. Accepted vibratory signals of *T. tuerki* were recorded and transformed into oscillogramms on the computer using the program Sound Forge 8.0 (Sony Pictures Digital, Inc.) and Sonic Visualiser (Free Software Foundation, Inc.).

All the vibratory signals consist of more or less distinct pulses united into rhythmically repeated sound groups — echemes and sequences (Benediktov & Zhantiev, 2000). Three types of vibratory signals of pygmy locusts were previously indicated (Benediktov, 2002), and the following classification of signals was used: signals of Type I — sequences of sound echemes of high and low amplitude which were mutually alternate (e. g. pairs of different echemes); signals of the Type II — single echemes, which was constantly repeated with well expressed and recognizable pulsar structure; signals of the Type III — sequences of repeated echemes without clear internal order.

Systematics

T. tuerki includes 2 subspecies: *T. tuerki tuerki* occurs in the European mountains (including Ukrainian Carpathians), and *T. tuerki orientalis* Harz, 1979, is recorded from Tajikistan (Harz, 1979; Devriese, 1996, 2004).

General Distribution of Nominative Subspecies

Mountains of Europe (Albania, Austria, Bulgaria, Czech Republic, France, Germany, Greece, Hungary, Macedonia, Montenegro, Poland, Romania, Serbia, Slovakia, Switzerland, Turkey (Thrace), Ukraine) (Łomnicki, 1905; Якобсон, Бианки, 1905; Бей-Биенко, 1951; Bazyluk, Liana, 2000; Harz, 1960, 1975; Devriese, 1996, 2004; Heller, 2004; Űnal, 2007).

Material examined. Ukraine: Lviv Region: 2 ♀, city of Staryi Sambir, flood-lands of Dniester River, 16.06.2006; 2 ♂, 1 ♀, Skole District., village Verkhnie Synievydne, flood-lands of Stryi River, 5.05.2008; 3 ♂, 11 ♀, city of Stryi, flood-lands of Stryi River, 17.06.2006, 06.07.2007, 27.04.2008; 3 ♀, 1 lrv. of last instars, city of Zhydachiv, flood-lands of Stryi River; 1 ♀, Zhydachiv District., village Zalissya, flood-lands of Stryi River near the fusion with Dniester River, 28.04.2008; 1 ♀, 1 lrv. of last instars, Zhydachiv District, village Zhuravno, flood-lands of Svicha River, 29.04.2008; 1 ♀, 1 lrv. of last instars, village Zhuravno, flood-lands of Svicha River near the fusion with Dniester River, 29.04.2008; Ivano-Frankivsk Region: 2 ♀, 1 lrv. of middle instars, city of Ivano-Frankivsk, flood-lands of Bystrytsya Nadvirnyanska River, 22.07.2008; 6 ♂, 17 ♀, 26 lrv. of middle instars, Dolyna District, village Goshiv, flood-lands of Svicha River, 6.07.2007; 14 ♂, 19 ♀, 5 lrv. of middle instars, 1 lrv of last instars, Verkhovyna District, village Kryvorivnya, flood-lands of Chorny Cheremosh River, 22.07.2007, 21.07.2008 (SIZK); 4 ♀, city of Ivano-Frankivsk, village Mykytyntsi, flood-lands of Bystrytsya Nadvirnyanska River, 3–8.10; 2 ♀, Bogorodchany District, village Starunya, flood-lands of Manyavka River, 15.09, (NSML); Zakarpattya Region: 1♂, 1 ♀, 1 lrv. of middle instars, Velyke Berezne District, railway station Sil', flood-lands of Uzh River, 30.04.2008; 2♂, 3 ♀, Perechyn District, village Dubrynychi, flood-lands of Uzh River, 30.04.2008; 2 ♂, 1 ♀, Perechyn District, village Dubrynychi, flood-lands of Lyutyanka River near the fusion with Uzh River, 30.04.2008; 1 ♀, 1 lrv. of last instars, city of Svalyava, flood-lands of Latoritsya River, 1.05.2008; 3 ♂, 6 ♀, city of Khust, flood-lands of Tisa River, 1.05.2008 (SIZK); Romania: 1 ♀, «Ciucea, 7.04.1960. Kis B. (leg. et det.)»; Bulgaria: 1 ♂ «Asenova krepost, r. Tschepelare 8.06.1960. Peschev leg., B-Bienko det.» (ZISP).

Our material was compared with the photographs of syntypes, which have the labels: 1 ♂, 1 ♀, «Austria, Vienna, det. H. Krauss»; 1 ♂, 2 ♀ «Yugoslavia, Moravica (Serbia), 13.05.1893, coll. Brunner v. W., det. Krauss» (SMNS).

Morphology and variability

The coloration of body of *T. tuerki* is rather uniform: grey or brown, with two dark and feebly marked spots on dorsal surface of prothorax or without it. Fore and mid femora widened, 1.1–1.2 times wider than maximum width of the visible part of tegmen. The anterior part of prothorax is roof-like, without lateral carinae. The further part of prothorax is flat and has well-marked lateral carinae, wide shoulders and low, but distinctive median carina. Median carina of prothorax is raised dorsally higher than the two lateral carinae. The larvae of *T. tuerki* have a roof-like prothorax, which is similar to that in the larvae of *T. tenuicornis*.

Adults and larvae of *T. tuerki* differ from others Carpathian pygmy locusts by the presence of a transverse depression on a frontal ridge and by a nearly equal width of the fore and mid femora with sinuous ventral keel.

T. tuerki is represented in the Ukrainian Carpathian Mountains by three different morphological forms: brachypterous, mesopterous and macropterous (26%, 66% and 8% in all samples accordingly) (fig. 1).

The original morphometric data were obtained by measuring of specimens of *T. tuerki* collected only on the territory of Ukraine.

The morphometric data of *T. tuerki*:

Brachypterous form (n = 16) ♂: BL_1 = 8.2–8.6; BL_2 = 7.2–8.1; FI = 5/1.5–5.3/1.9; PL = 7.6–7.7; PH = 2.25; PI = 3.4 (3.37–3.42); TL = 1.6; WL = 5.6–6.3; SI =2.75; ♀: BL_1 = 9.9–11.2; BL_2 = 9.7–11.4; FI = 5.8/2.1–6.5/2.3; PL = 8.4–9.7; PH = 2.75; PI = 3.3 (3.05–3.52); TL = 1.8–2.1; WL = 6.5–7.2; SI = 2.7; VI = 2.85.

Mesopterous form (n = 29) ♂: BL_1 = 8.1–9.5; BL_2 = 6.5–8.2; FI = 4.2/1.6–5.3/2.1; PL = 8–8.5; PH = 2.2; PI = 3.77 (3.68–3.86); TL = 1.5–1.6; WL = 6.3–6.7; SI = 2.75; ♀: BL_1 = 9.2–12.2; BL_2 = 7.8–11.5; FI = 5.3/1.9–6.3/2.3; PL = 8.6–10; PH = 2.7; PI = 3.44 (3.19–3.7); TL = 1.8–2; WL = 7.5–8.2; SI = 2.65; VI = 2.8.

Macropterous form (n = 5) ♂: BL_1 = 10.6–11.3; BL_2 = 8.2–9.2; FI = 4.2/1.9–4.7/2; PL = 10.2–10.7; PH = 2.2; PI = 4.75 (4.63–4.86); TL = 1.7; WL = 9.2; SI = 2.75; ♀: BL_1 = 12.8–13.1; BL_2 = 10.7–11.2; FI = 6/2.1–6.2/2.2; PL = 11.5–12.5; PH = 2.8; PI = 4.28 (4.1–4.46); TL = 1.8–2.1; WL = 10–11.5; SI = 2.85; VI = 2.94.

Morphological forms can be clearly separated by the length of wing. Additionally, three morphological forms of males of *T. tuerki* and two forms of females (mesopterous and macropterous forms) can be distinctly separated by the PI, while PI of

brachypterous and mesopterous females is partially overlapped. This overlapping is connected with a significant variability of size of protuberance of prothorax and length of femora of mesopterous form.

Our research revealed that the length of the body of imago of *T. tuerki* is maximal in the middle flow of rivers and decreased in the upper and lower flow of the mountain rivers (fig. 3). It was also recorded that the size of body of *T. tuerki* is decreasing from the north-east to south-west of the Ukrainian Carpathian mountains. The specimens of a smallest size were collected near the Tisa River in the vicinity of the city Khust.

Distribution area and habitat of *T. tuerki* in Ukraine

T. tuerki was recorded to inhabit mainly sandy or sandy-pebble alluvion places on the floods of mountain rivers at the heights about 500–2000 m a. s. l. (Jakobson, Bianchi, 1905; Harz, 1960, 1975).

The samples of *T. tuerki* were collected in different localities of the Carpathian Mountains in different natural habitats: along the Dniester, Opir, Stryi, Svicha, Bystrytsya, Berezhnicya, Prut, Chorny Cheremosh, Lyutyanka, Latoritsya, Tisa and Khustets Rivers. Various biotopes (meadows, sandy and stony banks, forest edges along river valleys from the headwaters to the low flows of mountain rivers, etc.) were examined, density of populations of *T. tuerki* was estimated for all habitats, and a comparative analysis of biotopes regarding their suitability for the presence of *T. tuerki* was carried out (fig. 2). As a result, *T. tuerki* was found only on sandy-pebble alluvion on mountain river banks.

T. tuerki is not found in valleys of mountain rivers, where banks consist of big stones, and along small rivers and streams shaded by trees (for example, near the Opir River in the locality N 6; near the Berezhnitsya River in the locality N 9 and near the Khustets River in the point N 25), but it inhabits the environs of low flows of rivers with sandy-pebble alluvion banks and prefers the places not shaded by coastal trees.

The population density of *T. tuerki* were studied in some selected areas on upper flows of larger mountain rivers mainly with the pebble banks and less often with the sandy-pebble alluvion. The average number of collected specimens of *T. tuerki* for all these habitats was 3.8 specimens per hour of collecting with the range between 3 to 10

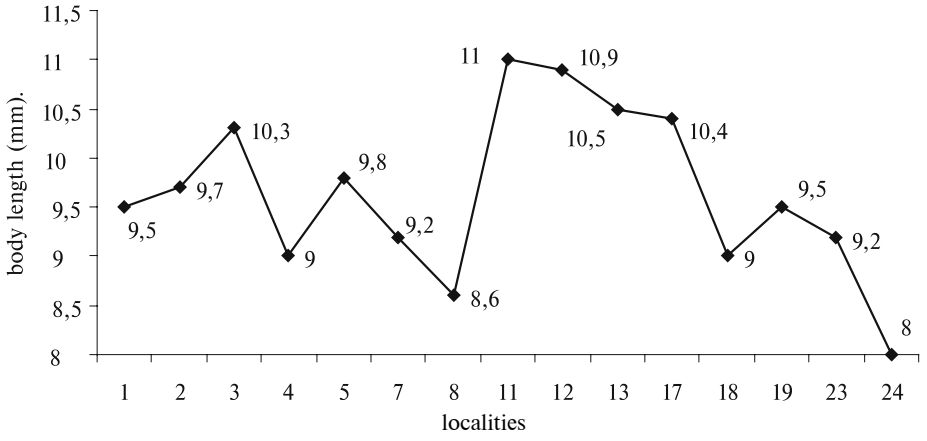

Fig. 3. Geographical regularity of variability of the body length of *T. tuerki* (on the example of ♀ mesopterous form). Vertical axis shows body length mean (BL_2), horizontal axis (1–24) — collecting localities (see also fig. 2).

Рис. 3. Географическая закономерность изменения размеров тела у *T. tuerki* (на примере ♀ среднекрылой формы). Вертикальная ось — середняя длинна тела (BL_2); горизонтальная ось (1–24) — точки сбора материала (также см. карту на рис. 2)

specimens (3 spec./hour near the Dniester River in the locality N 1; 2 spec./hour near the Stryi River in the locality N 2; 10 spec./hour at the Chorny Cheremosh River in the locality N 12; 3 spec./hour — at the Uzh River in the locality N 17; 2 spec./hour at the the Latoritsya River in the locality N 23, and 3 spec./hour at the Lyutyanka River in the locality N 19).

On the borders of Carpathian Mountains and their foothills (in Prikarpattya and Zakarpattya), where sandy-pebble alluvions along the river coasts are increased, the average number of specimens of *T. tuerki* grows up to 6.4 spec./hour (6 and 4 spec./hour near the Stryi River in the localities N 3 and N 4 correspondingly; 10 spec./hour near the Svicha River in the locality N 11; 5 spec./hour near the Uzh River in the locality N 18; 7 spec./hour near the Tisa River in the locality N 24).

In the lower flows of mountain rivers where sandy-pebble alluvion sediments much less developed, the average number of *T. tuerki* decreased to 2.3 spec./hour (2 spec./hour near the Stryi River in the locality N 5; 2 spec./hour near the Svicha River in the locality N 7; 1 spec./hour near the Svicha River in the locality № 8; 3 spec./hour near the Bystrytsya River in the locality N 13). At last, *T. tuerki* completely absents in the places where sandy-pebble alluvions disappeared or the mountain river became flatten (the Dniester River in the place of fusion with the Stryi and Svicha Rivers near the locality N 5 and the locality N 8; the Prut River in the locality N 26; the Uzh River in the locality N 20 and the Latoritsya River in the locality N 21 and N 22) (fig. 2).

As a result, it is shown that preferable habitats of *T. tuerki* are river banks with well developed sandy-pebble alluvion sediments on the middle flows of mountain rivers, especially on the foothills outside the mountain system (fig. 4). Density of *T. tuerki* decreases in the upper flows of mountain rivers, where sandy-pebble alluvion becomes less developed, but also in the direction to the lower flows of mountain rivers, where river banks gradually become flatten. Moreover, they completely disappear in the places of the upper flows of mountain rivers, where alluvions consist only of big stones and near the fusion of the mountain rivers with plain rivers; additionally, *T. tuerki* is absent along the banks of small mountain rivers, which riverbeds are shaded by high trees.

Our current study revealed that all morphological forms of *T. tuerki* are well represented in the middle flows of mountain rivers with the greatest quantity of sandy-pebble alluvions. Only two morphological forms of *T. tuerki* (mesopterous and brachypterous) are present in the upper flows of mountain rivers with alluvions exclusively consisting of the pebble, and in the lower flows of mountain rivers with gradually flatten river banks.

It was indicated that macropterous individuals of *T. tuerki* dominates at the middle flows of mountain rivers. For example, in July 2006–2008 on the flood-lands of Stryi River near the city of Stryi about 67% of total number of specimens belong to this form, and about 34% of the specimens collected during all periods of our study (fig. 2, the locality N 3; fig. 5, the locality N 3a-3c).

Mesopterous individuals dominates in the upper and lower flows of mountain rivers. For example, in the flood-lands of Chorny Cheremosh River near the village Kryvorivnya (about 80% of the total number of specimens collected during April-July, 2007–2008) (fig. 2, the locality N 12; fig. 5, the locality N 12).

We suggest that it could be connected with the absence of flight's necessity for *T. tuerki* in the places with less open riverbeds (with the rare alluvions and shadowed river banks). It is also assumed that the optimal places for *T. tuerki* are presented near the middle flows of mountain rivers and near the foothills along the border of mountain system.

Current study of microbiotopes shows that the preferable habitats of the mesopterous and brachypterous individuals of *T. tuerki* are places between the first floodplain river terrace covered by grass vegetation, sandy and sandy-pebble alluvions in the riverbed. In these habitats *T. tuerki* prefers various wet depressions of alluvion in the

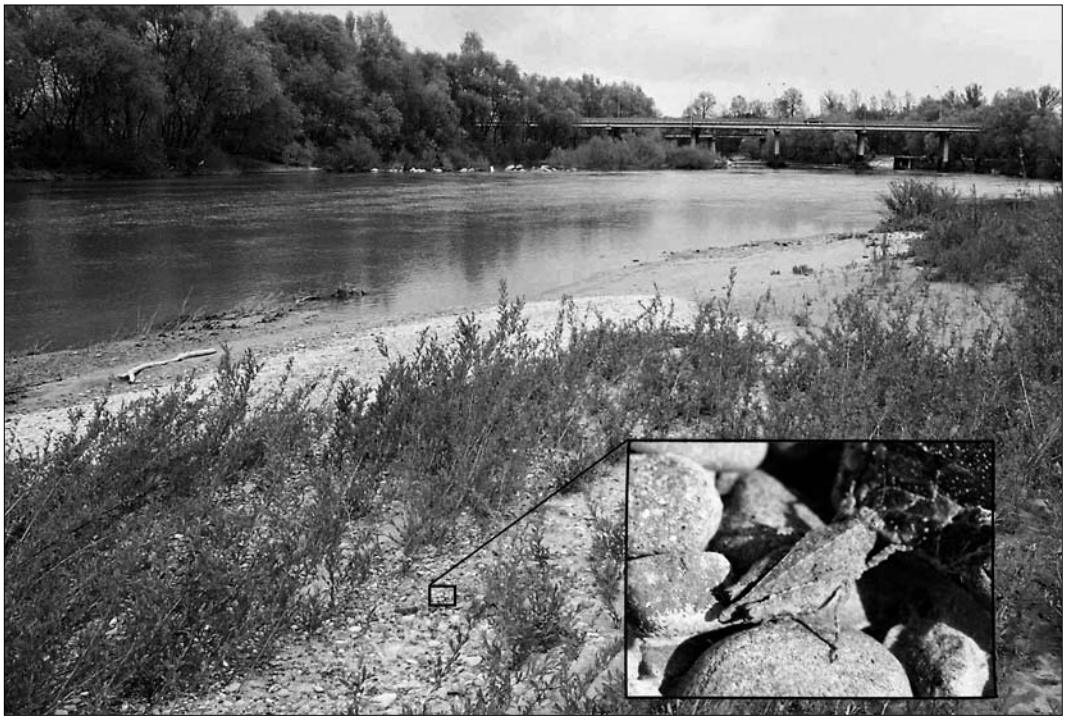

Fig. 4. Sandy-pebble alluvions of mountain rivers, the preferable biotope of *T. tuerki* — (Stryi River near Zhydachiv, Lviv Region).

Рис. 4. Песчано-галечниковые речные наносы — оптимальные стации для *T. tuerki* (р. Стрый возле г. Жидачева Львовской обл.).

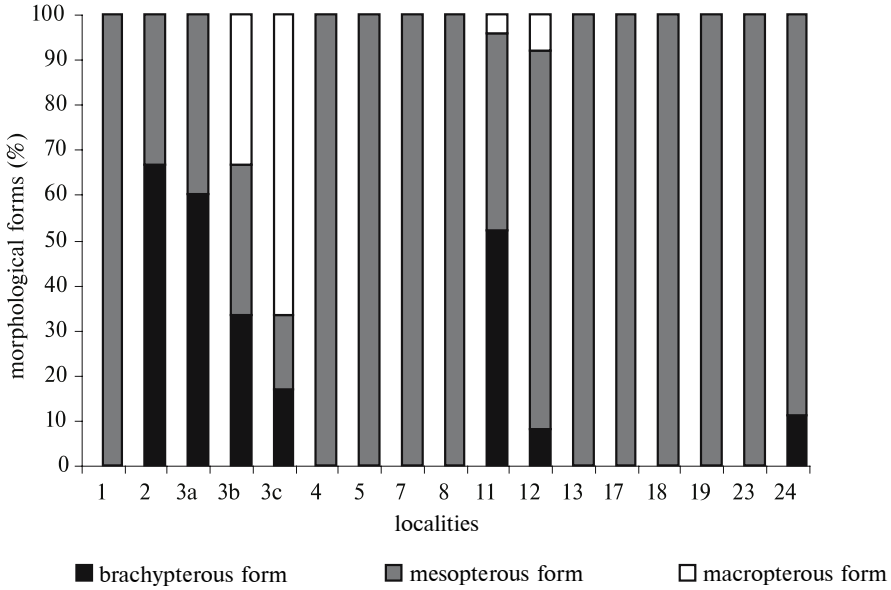

Fig. 5. Ratios of the morphological forms of *T. tuerki* in different localities. Vertical axis (1–100) shows percentage of morphological forms in one sample, horizontal axis (1–24) — localities (see also fig. 2).

Рис. 5. Соотношение морфологических форм *T. tuerki* в разных точках сбора материала. Вертикальная ось (1–100) — процент формы в пробе, горизонтальная ось (1–24) — точки сбора материала (также см. карту на рис. 2).

riverbed that are hidden from a wind and covered by little green grass and mosses vegetation (up to 10% covered) (fig. 6, *1*). Macropterous individuals of *T. tuerki* prefers sandy-pebble alluvions in the middle of the river far from its banks, where it inhabits some rare and small patches of grass vegetation formed around young willow trees grown on alluvions (fig. 6, *2, 3*).

We assume that the macropterous form of *T. tuerki* presence can be considered as an effective adaptation of the species for active migrations mainly across the rivers rather than along a riverbed, and an effective opportunity to avoid unfavorable living conditions during summer and autumn floods. On the other hand some adult insects can survive in the flood and be carried out by water to big distances.

Based on the obtained data, we establish the eastern borders of the area of nominative subspecies of *T. tuerki* in the Carpathian Region of Ukraine. It lies in the Prikarpattya region along the Dniester River from its upper reaches to Novyi Kalyniv in the vicinity of the town of Sambir. This species also distributed along the valleys of the Stryi, Svicha, Limnytsa and Bystrytsya Rivers up to the places before the fusion with the Dniester River, while in this region they are absent in the Dniester valley. *T. tuerki* is also located at the upper streams of the Prut River up to the vicinity of Chernivtsi.

In Zakarpattya region the borders of distribution of *T. tuerki* passes across the Uzh River between Perechyn and Nevicke, across the Latoritsya River between Svalyava and Chinadiyevo, across the Borzhava River near Irshava and then — across the Tisa River near Vilok. Current study show that the borders of distribution of *T. tuerki* in Ukraine mainly coincide with the boundaries of Carpathian Region. It is absent on the territory of Vododilno-Verkhovynski region of the Carpathian Mountains (along the strip of 20–50 km, which passes approximately on the border of Zakarpattya, Lviv and Ivano-Frankivsk Regions). In our opinion, it is connected with the absence of preferable biotopes of *T. tuerki* on that territory (fig. 2).

Fig. 6. Directions of seasonal changes of preferable biotopes in *T. tuerki* population in a flood-lands of Stryi River. *1* – hibernating place, April (the locality N 3a); *1*, *2* — June (the locality N 3b); *1*, *2*, *3* — July (the locality N 3c).

Рис. 6. Сезонная смена стаций у *T. tuerki* в пойме р. Стрый. *1* — место зимовки, апрель (точка № 3a); *1*, *2* — июнь (точка № 3b); *1*, *2*, *3* — июль (точка № 3c).

Life cycle of *T. tuerki* and food preferences

Our observations showed that *T. tuerki* hibernates on the phases of imago and larvae of last and middle instars. After winter, in April 2006–2008, the larvae reached up to 20–30% of total number of specimens in populations *T. tuerki* appeared after hibernation in the first or second decades of April, after spring floods in this region. *T. tuerki* hibernates mostly on the places with fruitful soil, often between roots of costal trees of the first floodplain terrace, outside and quite far from the river's alluvions (fig. 6, *1*).

We observed changes of natural habitats of *T. tuerki* during warm season. In the spring the mesopterous and brachypterous individuals were observed mainly on the first floodplain terrace of rivers or the border of floodplain terrace and sandy or sandy-pebble alluvion along the riverbeds (fig. 6, *1*). During the summer, mesopterous and brachypterous individuals of *T. tuerki* lived on the sandy or sandy-pebble alluvions, but macropterous individuals of *T. tuerki* is associated with small isolated islands of alluvions along the rivers (fig. 6, *2, 3*). The appearance of macropterous form on small river islands in the summer period shows the ability of *T. tuerki* to more active migrations.

Some data about life cycle and features of biology of *T. tuerki* were provided by Harz (1969). He described the eggs and the first instar larvae, indicated the time of oviposition, period of the emergence of the first instar larvae, and gave some brief data on feeding behavior of this species.

Our observations show that mating and oviposition of *T. tuerki* in the Ukrainian Carpathians occur in May. The larvae of the early instars of brachy- and mesopterous forms appear in the end of May — beginning of June, and their emergence completes in the middle of June, while larvae of macropterous form emerge a month later. In the beginning of July the number of larvae of *T. tuerki* of the middle (III–IV) instars consist up to 40–50% of the total number of specimens and then, at the end of July, the larvae of last (V) instar appear (fig. 7). Larvae of *T. tuerki* prefer to inhabit various wet depressions of coastal alluvions like adults of mesopterous and brachypterous forms.

Over 70% of larvae become adults the same year they emerged, but about 30% of them hibernate as middle and last instar larvae. The beginning of hibernation has not been recorded yet; however, it is supposed that it could start in the end of September or in the beginning of October, as in *T. tenuicornis* (our original unpublished data).

The ratio of number of specimens of different morphological forms of *T. tuerki* during the spring and summer seasons has been changing. Brachypterous and mesopterous individuals were collected during the whole warm season. The maximum number of mesopterous specimens was recorded in April (after hibernation) and brachypterous one — in May, while in spring macropterous one was not recorded. Adults of macropterous individuals developed from the hibernating larvae and appeared in June.

For example, in the valley of Stryi River, mesopterus and brachypterous forms of *T. tuerki* consist up to 100% of all specimens in populations in April (fig. 2, the locality N 3), but 67% of collected specimens belonged to the macropterous one in July (fig. 5, the localities N 3a-3c).

Based on our observation, the most important we suggest is that all (or most) hibernated larvae of *T. tuerki* transformed to the macropterous adults, but larvae, emerged the same year, transformed to the mesopterous and brachypterous adults (fig. 7).

It was noted that macropterous individuals of *T. tuerki* is important for the migration of this species and largely suffering and demolishing from unfavorable conditions during migrations. Since macropterous form was not found in spring, we suppose that these adults did not hibernate. That is why we assume that despite the most macropterous individuals could hibernate, the majority of them is perishing before winter.

We observed feeding behavior of *T. tuerki* under the laboratory conditions. Adult individuals of *T. tuerki* of all forms were kept in rearing cages with the substratum of

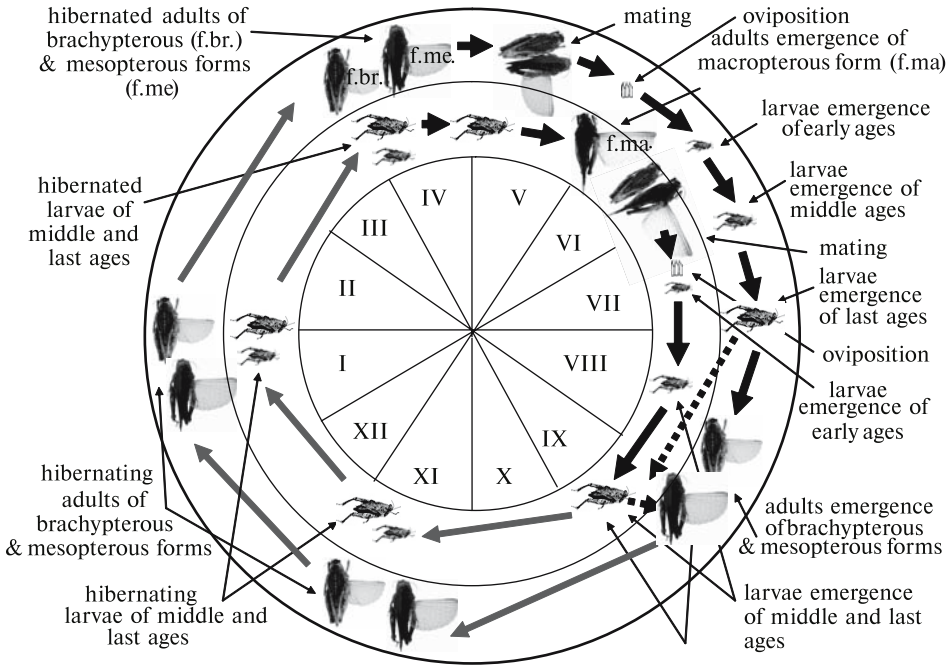

Fig. 7. Life cycle of different morphological forms of *T. tuerki*.

Рис. 7. Жизненный цикл разных морфологических форм *T. tuerki*.

mixed river sand and ooze, various mosses and dry and fresh plants, which were collected near natural habitats of *T. tuerki*. These observations revealed that the most preferable food of *T. tuerki* was the moss of the genus *Brium* Hedw. (Musci, Bryidae) and detritus of river ooze.

Vibratory communication

Several vibratory signals of *T. tuerki* are investigated at the laboratory for the first time. The signals of 6 males and 4 females collected near the flood-lands of the Stryi and Chorny Cheremosh Rivers were recorded using the equipment (see "Material and methods" chapter).

During our study the signals of the III type were recorded (the terminology after Benediktov, 2002). Based on our observations, it was assumed that the signals of the III type of *T. tuerki* probably are rivalry but not courtship signals. It was indicated that under laboratory conditions these signals were emitted only by the male during the presence of another male (fig. 8), or by the female in the presence of another female. We could not record any vibratory signals for other combinations of specimens of *T. tuerki* (i. e., single specimen of male or female, or female with male). The communication between males and females during the courtship has not been noticed in our current research yet. While producing vibratory signals the males and females of *T. tuerki* were making very frequent vibrations of their body.

Our observations showed that both females and males of *T. tuerki* do not produce any signals, while they are not disturbed, but in the cases of mutual disturbance they emitted vibration signals, for example, when observed individuals actively moved inside the laboratory cage and occasionally disturbed each other by a short-time crawling on another specimen. In such cases only disturbed individual produced certain vibratory signals, trying to avoid contacts with another individual.

Probably, these signals are rivalry, and as another individual accepts them it stops any contacts with the body of the other individual. It was also noticed that the dura-

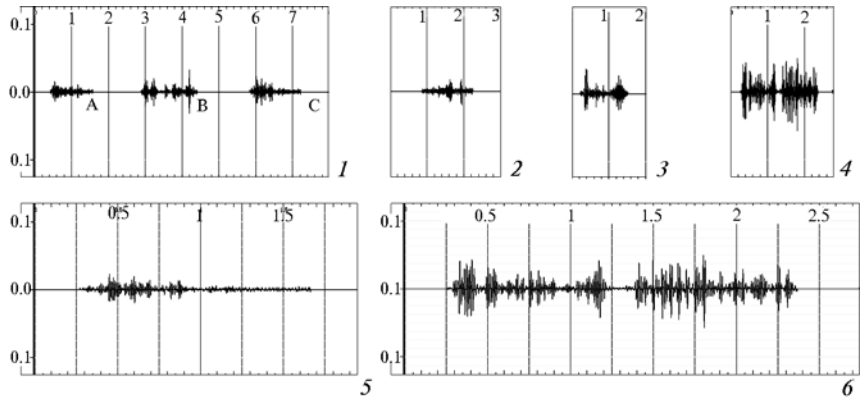

Fig. 8. Oscillograms of vibratory signals of *T. tuerki* (horizontal axis indicates the time, in seconds). *1–4* – variability of a signal sequences; *5* – oscillogram of the intermediate between the I and III types of signal sequence (*1C*); *6* — oscillogram the pair of typical sequences of the III type of signal (4).

Рис. 8. Вибрационные сигналы *T. tuerki* (по горизонтальной оси — время, в секундах). *1–4*– изменчивость сигналов; *5* — осциллограма сигнала, промежуточного между I и III типом (*1C*); *6* — осциллограмма двух типичных серий сигнала III типа (*4*).

tion of recorded vibratory signals depends on the time of direct body contacts between two specimens of *T. tuerki*.

It was previously considered that vibratory signals of pygmy locusts are accepted only through a substratum (Benediktov, 1998, 2002, 2005), but according to our observations, vibratory signals between two specimens were mainly mutually accepted by them during their direct body contacts rather than due to their contacts with the substratum.

The analysis of obtained data showed that the sequences of vibratory signals consists either of a series of single echemes (fig. 8, *2, 3, 5*) or repeated echemes during regular time intervals (fig. 8, *1, 4, 6*). It is preliminary assumed that some signals (see fig. 8, *1, 2, 3*) are intermediate between the I and III type signals. These signals were observed to consist of two parts: 1) echemes with alternated high- and low-amplitude of pulses, gradually continuing into 2) echemes without any clear internal structure (fig. 8, *1C*, *5*).

A. A. Benediktov (2001) indicated that the vibratory signals of some orthopterous insects can be transmitted only during direct contacts of fore and middle legs with a substratum. However, our observations revealed that the vibratory signals of *T. tuerki* were transmitted to the substratum both during direct contacts of fore and middle legs of individuals, and during direct contacts of the lower surface of thorax with the substratum. Thus, the intensity of vibratory signals of *T. tuerki* depends from the body position of individuals on the substratum. In cases of direct contacts of the lower surface of thorax of males with the substratum, the intensity of these signals was greatly increased, but the behavior of females was different: they virtually never touched the substratum with the thorax during transmission of any vibratory signals. As a result, the intensity of signals, transmitted to the substratum by the females, was much less intensive. These signals were very weak, but still noted and recorded. However, available equipment could not transform these recorded very weak female signals into recognizable oscillograms with any clear internal structure.

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Bazyluk W. Tetrigidae (Orthoptera) Polski // Fragmenta Faunistica — Warszawa, 1958 — 7, N 15. — P. 379–409.

Bazyluk W., Liana A. Prostoskrzydłe Orthoptera // Katalog fauny Polski. — Warszawa : MIIZ PAN, 2000. — Część 17, zeszyt 2. — 157 s.

Benediktov A. A. Acoustical communication of pygmy locusts of genus Tetrix (Orthoptera, Tetrigidae) // Russian Journal of Zoology. — 1998. — **77** (9). — P. 1021–1025. — Russian : *Бенедиктов А. А.* Акустическая коммуникация прыгунчиков рода Tetrix (Orthoptera, Tetrigidae) // Зоологический журнал. — 1998. — **77** (9). — С. 1021–1025.

Benediktov A. A., Zhantiev R. D. Vibrational communication in Orthoptera // Abstract book I. XXI International Congress of Entomology (August 20–26). — Brazil, 2000. [1734]. — P. 438.

Benediktov A. A. New data about vibrational communication of orthopterous insects of family Tetrigidae (Orthoptera) // Proceeding of VII international Ubusanur symposium (Kyzyl, 20–24 sept. 2001) — Moscow : Slovo, 2001. — P. 97–106. — Russian : *Бенедиктов А. А.* Новые данные о вибросигнализации прямокрылых семейства Tetrigidae (Orthoptera) // Труды VII Убсунурского международного симпозиума (Кызыл, 20–24 сент. 2001 г.). — М. : Слово, 2001 — С. 97–106.

Benediktov A. A. Courtship acoustical behaviour of a cricket Arachnocephalus vestitus (Orthoptera, Mogoplistidae) // Vestnik of Moscow State University, series biology — Moscow, 2001 — N 1. — P. 12–15. — Russian : *Бенедиктов А. А.* Прекопуляционное акустическое поведение сверчка Arachnocephalus vestitus (Orthoptera, Mogoplistidae) // Вестник Московского ун-та. Сер. Биол. — М., 2001. — № 1. — С. 12–15.

Benediktov A. A. Vibrational signals orthopterous insects of family Tetrigidae (Orthoptera) // Proceeding of Russian Entomological Society. — Saint-Petersburg, 2005. — **76**. — P. 131–140. — Russian : *Бенедиктов А. А.* Вибрационные сигналы прямокрылых насекомых семейства Tetrigidae (Orthoptera) // Тр. Русского энтомол. об-ва. — СПб., 2005. — **76**. — С. 131–140.

Bey-Bienko G. Y. Family Tetrigidae (=Acrydiidae) // Locusts of the USSR and contiguous countries fauna / G. Ya. Bey-Bienko, L. L. Mistshenko. — Moscow ; Leningrad, 1951. — Vol. I. — P. 83–107. — Russian : *Бей-Биенко Г. Я.* Семейство Tetrigidae — тетригиды, или прыгунчики (=Acrydiidae) // Саранчовые фауны СССР и сопредельных стран / Г. Я. Бей-Биенко, Л. Л. Мищенко. — М. ; Л. : Изд-во АН СССР, 1951. — Т. 1. — С. 83–107.

Bey-Bienko G. Y. Superfamily Acridoidea // Keys to the insects of the European Territory of the USSR. Vol. I. Keys to the USSR fauna published by ZIN AN SSR / Ed. G. Y. Bey-Bienko. — Moscow; Leningrad : Nauka, 1964. — P. 243–284. — Russian : *Бей-Биенко Г. Я.* Надсемейство Acridoidea — саранчовые // Определитель насекомых европейской части СССР : В 5 т. / Под общ. ред. Г. Я. Бей-Биенко. — М. ; Л. : Наука, 1964. — Т. I. — С. 243–284.

Chetyrkina I. A. Some data on the locusts' fauna (Orthoptera, Acridoidea) in Transcarpathian Region of Ukraine // Proceedings of AN SSR. — 1950. — **70**, N 4. — P. 729–732. — Russian : *Четыркина И. А.* Некоторые данные по фауне саранчевых (Orthoptera, Acridoidea) Закарпатской Украины // Доклады Академии наук СССР. — 1950. — **70**, — N 4. — С. 729–732.

Devriese H. Bijdrage tot systematiek, morfologie en biologie van de West-Palearktische Tetrigidae // Lettre de contact Saltabel. — 1996. — N 15. — P. 2–38.

Devrice H. Tetrigidae. Orthoptera Species File Online version 2. — 2004. — Internet-resource, access: http: // osf2.orthoptera.org.

Harz K. Gerad-flügler oder Orthopteren (Blattoptera, Mantodea, Saltatoria, Dermatoptera) // Die Tierwelt Deutschlands. — Jena, 1960. — 232 p.

Harz K. Die Orthopteren Europas. II. — Hague, 1975. — 939 p.

Harz K. Zwei neue Tetrix-Unterarten aus Tadshikistan (Orthoptera, Caelifera) // Articulata. — 1979. — **1**(13). — P. 127–128.

Heller K.-G. Fauna Europea: Tetrigidae. Fauna Europea version 1.1. — 2004. — Internet-resource, access: http:// faunaeur.org.

Heller K.-G., Korsunovskaya O., Ragge D. R. et al. Check-List of European Orthoptera // Articulata — Erlangen. — 1998. — Beiheft 7. — S. 1–61.

Jakobson G. G., Bianchi V. L. Insecta Orthoptera and Pseudoneuroptera of Russian Empire and bordering countries. — St. Petersburg : 1905. — 952 p. — Russian : *Якобсон Г. Г., Бианки В. Л.* Прямокрылые и ложносетчатокрылые Российской империи и сопредельных стран. — СПб., 1905. — 952 с.

Krauss H. A. Tettix Tűrki nov. spec. (Orthopt.) // Entom. Monatsbl. — Berlin, 1876. — N 1. — P. 103–104.

Likovich I. M. Studies on vertical distribution of orthopterous insects (Orthoptera) in Transcarpathian Region // Scientific proceedings Uzhhorod state university (Soviet Carpathians fauna). — Uzhhorod, 1959. — Vol. 40. — P. 227–238. — Russian : *Ликович И. М.* К вопросу о вертикальном распределении прямокрылых (Orthoptera) в Закарпатье // Науч. зап. Ужгородск. гос. ун-та. — Ужгород, 1959. — **40**. — С. 227–238. — (Фауна и животный мир советских Карпат)

Likovich I. M. Peculiarity of orthopterous insects (Orthopteroidea) fauna and ecology in Ukrainian Carpathians and it modification under the antropogenic factor influence // Proceeding of VII international symposium of Middle Europe entomofauna (Leningrad, 19–24 sept. 1977). — Leningrad, 1979 — P. 355–357. — Russian : *Ликович И. М.* Особенности фауны и экологии ортоптероидных насекомых (Orthopteroidea) Украинских Карпат и ее изменение под влиянием антропогенного фактора // Материалы VII Международ. симп. по энтомофауне Средней Европы (Ленинград, 19–24 сент. 1977 г.). — Л., 1979. — С. 355–357.

Likovich I. M. Ecology and faunal description of orthopterous insects of Ukrainian Carpathians // Proceedings of IX congress of All-Union Entomological Society (Kyiv, October, 1984). — Kyiv :

Naukova dumka, 1984. — P. 15. — Russian : *Ликович И. М.* Эколого-фаунистическая характеристика прямокрылых Украинских Карпат // Тезисы докладов IX сьезда Всесоюзного энтомол. об-ва, (Киев, октябрь 1984). — Киев : Наукова думка, 1984. — С. 15.

Łomnicki [A] M. Szaranczaki nowe dla fauny galicyjskej // Spraw. Kom. fizjogr. — Krakow, 1905. — **13**. — S. 124–129.

Podgornaya L. I. Biological peculiarities of pygmy locusts (Orthoptera, Tetrigoidea) // Proceedings of All-Union Entomological Society. — Leningrad : Nauka, 1981. — Vol. 63 — P. 44–45. — Russian : *Подгорная Л. И.* Биологические особенности тетригидовых (Orthoptera, Tetrigoidea) // Тр. Всесоюзн. энтомол. об-ва. — Л. : Наука, 1981. — Т. 63. — С. 44–45.

Podgornaya L. I. Orthopterous insects of family Tetrigidae (Orthoptera) USSR fauna. Proceedings of ZIN AN SSR — 1983. — **112**. — 95 p. — Russian : *Подгорная Л. И.* Прямокрылые насекомые семейства Tetrigidae (Orthoptera) фауны СССР // Тр. Зоол. ин-та АН СССР. — 1983. — **112**. — 95 с.

Pravdin F. N., Guseva V. S., Kritskaya I. G., Chernyakhovskyi M. Y. Some investigation foundations and receiving of mixed population of solitaries locusts in different landscape conditions // Animal fauna and ecology — Moscow, 1972. — P. 3–16. — Russian : *Правдин Ф. Н., Гусева В. С., Крицкая И. Г., Черняховский М. Е.* Некоторые принципы и приемы исследования смешанных популяций нестадных саранчовых в разных ландшафтных условиях // Фауна и экология животных. — М., 1972. — С. 3–16.

Projekt DORSA — Zoologisches Forschungsinstitut und Museum Alexander Koenig, Bonn / SysTax, 2008 — Internet-resource, access : http: // www.biologie.uni-ulm.de/systax

Pushkar T. I. Pygmy locusts (Orthoptera, Tetrigidae) of the Wood-and-Steppe Zone of Ukraine // The Kharkov Entomological Society Gazette — 2005 (2006). — Vol. 13, is. 1–2. — P. 9–18. Russian : *Пушкар Т. И.* Тетригиды (Orthoptera, Tetrigidae) Лесостепи Украины // Изв. Харьков. энтомол. об-ва. — 2005 (2006). — **13**, вып. 1–2. — С. 9–18.

Storozhenko S. Yu., Paik J-Ch. Orthoptera of Korea. — Vladivostok : Dalnauka, 2007 — 232 p.

Ünal M. Checklist of Turkish Orthoptera. — 2007. — Internet-resource, access : http: // members.tripod.com/Cesa88/orthtr.htm.