

On taxonomic identification of *Handianus imperator* Dlabola, 1961 and *H. alatavicus* Emelyanov, 1964 (Homoptera: Cicadellidae: Deltocephalinae: Athysanini)

О таксономической идентификации *Handianus imperator* Dlabola, 1961 и *H. alatavicus* Emelyanov, 1964 (Homoptera: Cicadellidae: Deltocephalinae: Athysanini)

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КЛЮЧЕВЫЕ СЛОВА: цикадки, морфология, изменчивость, вибрационные сигналы, распространение, Казахстан, Средняя Азия.

ABSTRACT. Illustrated redescriptions of *Handianus imperator* and *H. alatavicus* with data on the variability of the shape of the aedeagus, acoustic signals, biology, and distribution are presented. These species distinctly differ in morphology, although the length and shape of processes of the aedeagus in *H. alatavicus* are variable, and some authors misidentified its variation with long processes as *H. imperator*. Despite similar ecological preferences and host specializations, these species are allopatric. *H. imperator* occurs in Kyrgyzstan and Uzbekistan, while *H. alatavicus* was found only in one location in northern Kyrgyzstan and is widespread throughout southern and southeastern Kazakhstan. The male calling signals of these species are identical, but due to allopatry they apparently do not come into acoustic contact with each other, so the similarity of signals does not prevent successful intraspecific communication. A similar situation was recently described in two other species of *Handianus*, which are also well distinguished by morphology, live on the same host, do not differ in environmental preferences, produce similar calling signals, but were never found in the same locality.

РЕЗЮМЕ. Приведены иллюстрированные переписания *Handianus imperator* и *H. alatavicus* с данными по изменчивости формы эдеагуса, акустическим сигналам, биологии и распространению. Показано, что эти виды четко различаются по морфологии, хотя длина и форма отростков эдеагуса у *H. alatavicus* изменчивы, в связи с чем некоторые ав-

торы ошибочно идентифицировали его вариацию с длинными отростками как *H. imperator*. Несмотря на сходные экологические предпочтения и кормовую специализацию, данные виды аллопатричны. *H. imperator* встречается в Кыргызстане и Узбекистане, в то время как *H. alatavicus* известен только из одной точки в северном Кыргызстане и широко распространен по всему южному и юго-восточному Казахстану. Призывные сигналы самцов этих видов идентичны, однако благодаря аллопатрии они вероятно не вступают в акустический контакт друг с другом, поэтому сходство сигналов не препятствует успешной внутривидовой коммуникации. Аналогичная ситуация недавно была описана у двух других видов *Handianus*, которые также хорошо различаются по морфологии, живут на одном и том же кормовом растении, имеют одинаковые экологические предпочтения, издают сходные призывные сигналы, но при этом никогда не были найдены в одной точке.

Introduction

The genus *Handianus* Ribaut, 1942 (Homoptera: Cicadellidae: Deltocephalinae: Athysanini) includes about 40 Palearctic species, most of which occur in arid regions of Central Asia [Dmitriev *et al.*, 2022 onward]. Emelyanov [1964b] provided an illustrated key to 26 species of *Handianus*, 12 of which he described as new. Afterwards, the key to species of *Handianus* of Kazakhstan was published by Mityaev [1971].

Some species of *Handianus* are similar in appearance and in the shape of the male genitalia. In addition, in some species, the shape of processes of the aedeagus, which is one of the main species-specific characters in this genus, is variable. Also, a case of similarity of the male calling signal patterns in two morphologically different species was described [Tishechkin, 2023]. Thus, identification of some species of *Handianus* presents some difficulties, and even the use of acoustic analysis in this situation does not always solve the problem.

In particular, this applies to *Handianus imperator* Dlabola, 1961 and *H. alatavicus* Emelyanov, 1964. The shape of the aedeagus of *H. imperator* in the drawings in the works of different authors differs greatly and sometimes is similar to that of *H. alatavicus* [Dlabola, 1961; Emelyanov, 1964b; Dubovskiy, 1966; Mitjaev, 1971]. This indicates incorrect identification of these species by some authors and, as a consequence, the need to revise all data on their distribution. To clarify this situation, we studied these species for several years in Kyrgyzstan and southern and southeastern Kazakhstan. This article presents illustrated descriptions of *H. imperator* and *H. alatavicus* with data on variability of the aedeagus, the male vibrational calling signals, biology, and distribution.

Material and methods

Leafhopper vibrational signals were recorded by means of portable recording equipment consisting of a piezocrystal gramophone cartridge GZP-311 connected to the microphone input of a cassette recorder Elektronika-302 (1994), minidisk recorder Sony Walkman MZ-NH900 (2014), or Roland R-05 wave/mp3 recorder (2017–2023) via a custom-made matching amplifier. For recording, a stem of the host plant about 10–15 cm in length was attached to the cartridge by a rubber ring with the cartridge needle slightly touching the stem. Then a nylon cage containing a male leafhopper was put on the twig. After some time, the male usually sat on the twig and started singing.

Oscillograms of signals were produced with Cool Edit Pro 2.1 software.

For elements of signal temporal pattern, the following terms are used. **Pulse** is a brief fragment of signal (or succession of sine waves) with rapid increase and subsequent decrease of amplitude, i.e. separated from similar fragments by amplitude minimums. Short fragments with more or less constant temporal pattern consisting of uniform or different pulses are referred to as **syllables**. Any more or less prolonged signal with complex pattern (e.g. succession of similar or different pulses or syllables) is referred to as a **phrase**.

Digital images of aedeagus were obtained with a Micromed 3 LED M microscope equipped with a MiChrome 5 Pro camera (Tucsen). The distribution map was produced using free software from www.simplemappr.net.

Materials examined are deposited in the collection of the Zoological Museum of M.V. Lomonosov Moscow State University.

Species descriptions

Handianus imperator Dlabola, 1961
Figs 1–7, 20–21, 27–28, 34.

DESCRIPTION. Pale yellowish with four black spots in fore part of vertex and with indistinct dark pattern on pro- and mesonotum (Fig. 1).

Pygofer lobes with notches on outer edges and with small subapical denticles directed outward. Subgenital plates with single marginal rows of macrosetae and with several randomly arranged macrosetae in apical parts.

Aedeagus T-shaped, with two pairs of processes (Figs 2–7). Anterior processes short, directed basally, straight or slightly sinuate. Posterior processes long, bifurcated, bent inward, longer branches with apical expansions, reach each other or even cross.

The shape of the aedeagus in different specimens differ only slightly in the position of the posterior processes. In general, males from the Inner Tien Shan (Figs 4–5) do not have significant differences in this trait from males from the low arid mountains in the environs of Tash-Kumyr, West Tien Shan (Fig. 6) and Osh (Fig. 7).

MALE CALLING SIGNALS. Signals of males from the following localities were investigated (Fig. 34).

1. Kyrgyzstan, Inner Tien Shan, steppe on the right bank of the Western Karakol River, ca 25 km east-northeast of the Suusamyrl Village, from *Artemisia* subg. *Seriphidium* (Asteraceae), 13.VII.2023, signals of two males recorded at 25 °C.

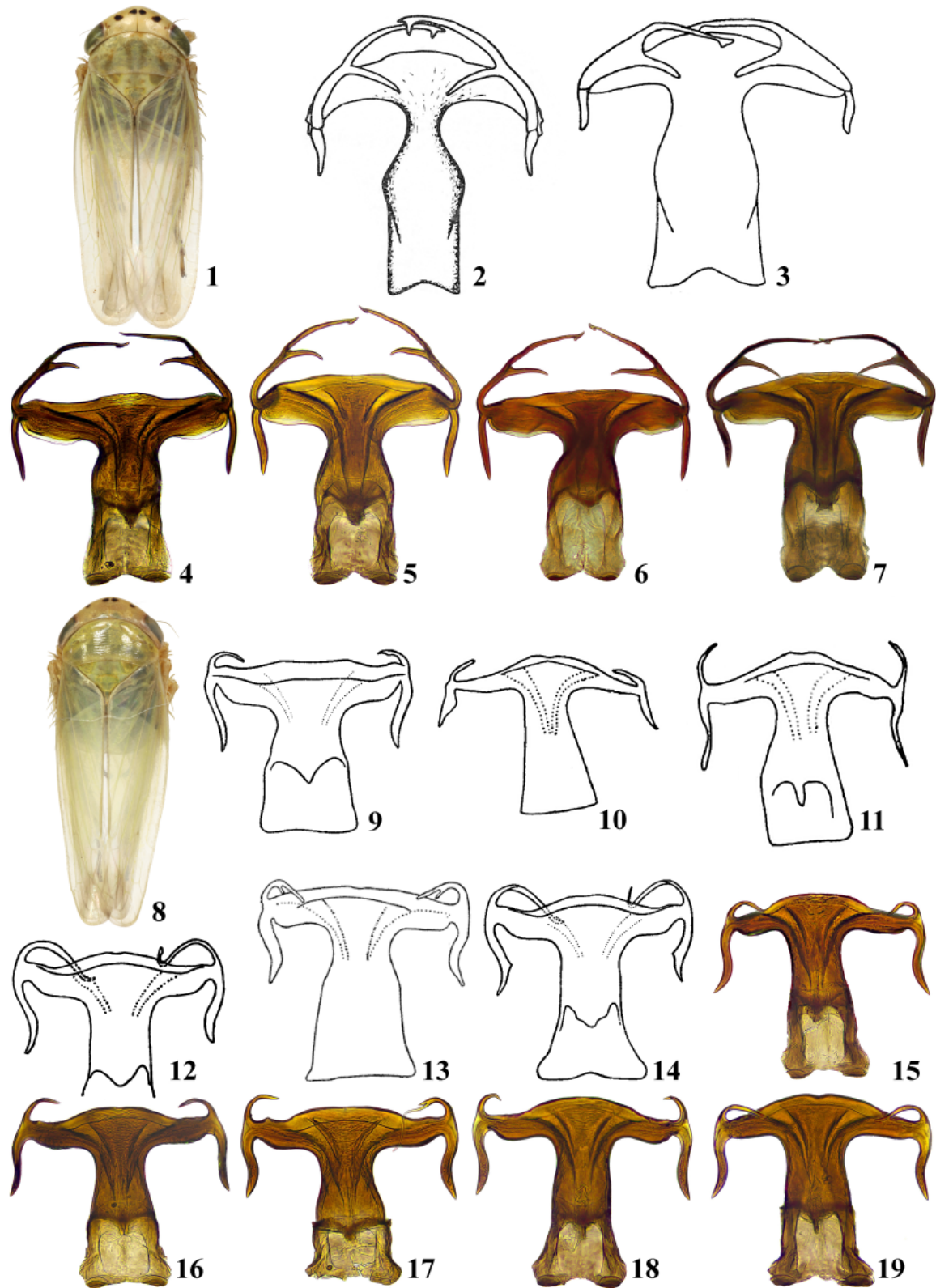
2. Kyrgyzstan, Inner Tien Shan, the Kekemeren (=Kokomeren) River 8–9 km downstream from Kozhomkul Village, mountain steppes on the left bank, from *Artemisia* sp., 27.VI.2014, signals of two males recorded at 23 and 26 °C.

Calling signal is a phrase increasing in amplitude and lasting for 2–3 s (Figs 20–21). A phrase consists of uniform pulses following at the rate of 17–18/s (Figs 27–28).

BIOLOGY. Was collected from *Artemisia* spp. In the Inner Tien Shan was found in mountain steppes with a rather cold climate at altitudes of about 2000 m. On the other hand, in the West Tien Shan and on Alai and Turkestan ranges it was collected in arid low mountains. Obviously, this indicates very broad ecological preferences of this species.

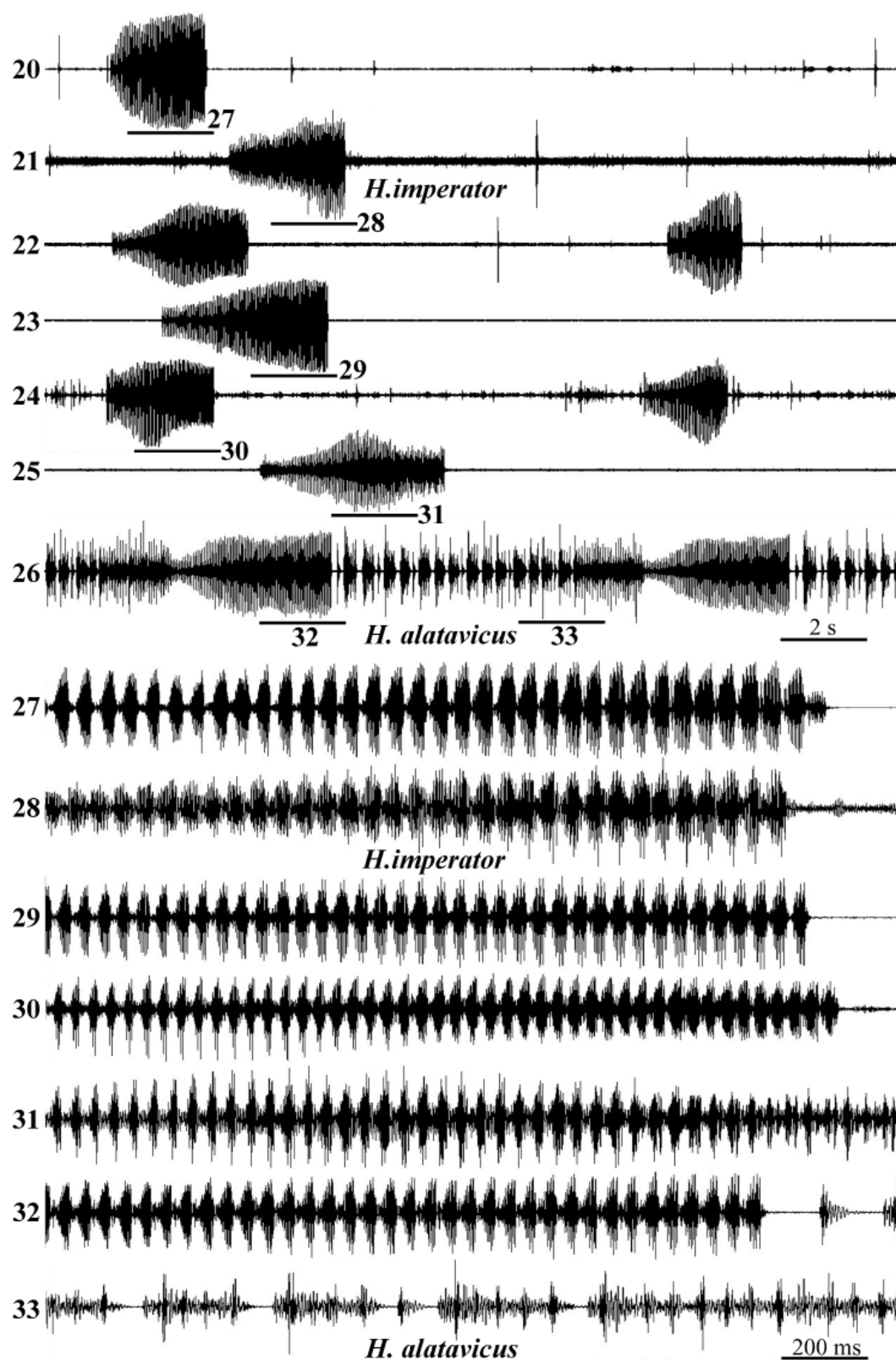
DISTRIBUTION. Kyrgyzstan, Uzbekistan. Records from Kazakhstan in Mityaev [1971, 2002, etc.] refer to *H. alatavicus* (see below). Record from European Russia in Emelyanov [1964a] also apparently refers to some other species, although due to the lack of drawings its identification is impossible.

REMARKS. Dlabola [1961] described *H. imperator* based on materials of Dubovskiy from Andijan, Uzbekistan. The drawings of the aedeagus in the works of Dlabola [1961] (Fig. 2) and Dubovskiy [1966] (Fig. 3) are similar and undoubtedly depict the species shown in our photographs (Figs 4–7). However, Emelyanov [1964b: 40, figs 132, 135] gives under the name *H. imperator* the drawings of some other species, most probably, of an atypical male of *H. alatavicus* with unusually long posterior processes of the aedeagus (Fig. 14). Mityaev [1971] showed that males with different lengths of processes belong to the same species (Figs 10–13). Unfortunately, he erroneously identified and recorded it from southern and eastern Kazakhstan as *H. imperator*, although actually this is *H. alatavicus* [Mitjaev, 1971, 2002].



Figs 1–19. *Handianus* spp. 1–7 — *H. imperator*; 8–19 — *H. alatavicus*. 1, 8 — dorsal habitus, 2–7, 9–19 — aedeagus, back view. 2 — after Dlabola [1961], 3 — after Dubovskiy [1966], 9 — after Emelyanov [1964b], 10–13 — after Mityaev [1971], listed as *H. imperator*, 14 — after Emelyanov [1964b], listed as *H. imperator*.

Рис. 1–19. *Handianus* spp. 1–7 — *H. imperator*; 8–19 — *H. alatavicus*. 1, 8 — общий вид сверху, 2–7, 9–19 — эдеагус сзади. 2 — по: Dlabola [1961], 3 — по: Дубовский [1966], 9 — по: Емельянов [1964b], 10–13 — по: Митяев [1971], приведён под названием *H. imperator*, 14 — по: Емельянов [1964b], приведён под названием *H. imperator*.



Figs 20–33. *Handianus* spp., calling signal oscillograms. 20–21, 27–28 — *H. imperator*, 22–26, 29–33 — *H. alatavicus*. Faster oscillograms of the parts of signals indicated as “27–33” are given under the same numbers. Scale mark “2 s” for oscillograms 20–26, scale mark “200 ms” for oscillograms 27–33.

Рис. 20–33. *Handianus* spp., осциллограммы призывных сигналов. 20–21, 27–28 — *H. imperator*, 22–26, 29–33 — *H. alatavicus*. Фрагменты сигналов, помеченные цифрами “27–33”, представлены на осциллограммах под соответствующими номерами. Отметка времени “2 s” — для осциллограмм 20–26, отметка времени “200 ms” — для осциллограмм 27–33.

Handianus alatavicus Emelyanov, 1964
Figs 8–19, 22–26, 29–34.

DESCRIPTION. Externally indistinguishable from *H. imperator* (Fig. 8). Shape of pygofer lobes and subgenital plates also same as in previous species.

Aedeagus T-shaped, with two pairs of processes (Figs 9–19). Anterior processes short, directed basally, straight or slightly sinuate, their length almost the same in different specimens. Posterior processes more or less bent inward (Figs 16–18) or even backward (Figs 15, 19). Occasionally, one or both posterior processes bifurcated (Fig. 17).

Despite the fact that the length and shape of posterior processes of the aedeagus is somewhat variable, males with different shape of processes sometimes were found in the same sample (for example, two males from Chu-Ili Mts. shown on Figs 18–19). For this reason, we share the opinion of Mityaev [1971] that differences in the shape of posterior processes of the aedeagus are the result of intraspecific variability.

MALE CALLING SIGNALS. Signals of males from the following localities were investigated (Fig. 34).

1. Southern Kazakhstan, Chu-Ili Mts., west of Korday Pass (ca. 170 km west of Almaty), steppe on mountain slope, from *Artemisia* subg. *Seriphidium*, 11.VI.2017, signals of two males recorded at 25 °C.

2. Southern Kazakhstan, steppe with *Artemisia* sp. in the environs of Chemolgan Town, 20 km west of Almaty, 8.VII.1994, signals of four males recorded at 27 °C.

3. Southeastern Kazakhstan, Dzhungarskiy Alatau Range, east of Zhansagurov Village, *Artemisia* subg. *Seriphidium* on dry mountain slope, 15.VI.2019, signals of one male recorded at 28 °C.

4. Southeastern Kazakhstan, foothills of Dzhungarskiy Alatau Range near the gorge of the Lepsy River at its exit from the mountains to the plain, 13 km south of Kolbay Village, from *Artemisia* subg. *Seriphidium*, 19.VI.2017, signals of two males were recorded at 30 °C.

Calling signal is a phrase lasting for 2–4 s (Figs 22–25); quite often phrases with different duration present in the song

of the same male (Figs 22, 24). The phrase consists of uniform pulses following at the rate of 20–23/s (Figs 29–30). In the most acoustically active males, another sequence of pulses is added at the end of a phrase (Figs 25, 31) or a sequence of syllables followed by a sequence of pulses appears between phrases (Figs 26, 32–33). In this way, individual simple phrases following at irregular intervals become more complex and transform into a continuous elaborate signal lasting up to several minutes.

BIOLOGY. Inhabits steppes in the foothills and low mountains. In all cases, was collected in plant communities dominated by wormwood (*Artemisia* spp.). During signal recording, readily fed and produced signals on wormwood.

DISTRIBUTION. Widespread throughout southern and eastern Kazakhstan, also, known from one geographical point in northern Kyrgyzstan (type locality; not shown on the map). Record from Uzbekistan [Dmitriev *et al.*, 2022 onward] needs verification. In Mityaev [2002], erroneously listed from Kazakhstan as *H. imperator*.

REMARKS. Emelyanov [1964b] described *H. alatavicus* based on three males and one female from the Dzhergalan River, eastern end of the Issyk-Kul Lake, Kyrgyzstan (Fig. 9). However, he attributed to this species only males with the aedeagus having short posterior processes curved inward; as mentioned above, he misidentified males with longer posterior processes as *H. imperator*. Later, Mityaev [1971] misidentified this species as *H. imperator* (see remarks on *H. imperator* above). We, following Mityaev [1971], also misidentified it as *H. imperator* in our article on vibrational signals of Cicadellidae [Tishechkin, 2000].

Discussion

Examples of variability of the male genitalia are described in many species of Auchenorrhyncha (Homoptera). Sometimes this variability has environmental or geographical nature [Wagner, 1967; Le Quesne, Woodroffe, 1976; Dmitriev, 1999; Gnezdilov, 1999]. There

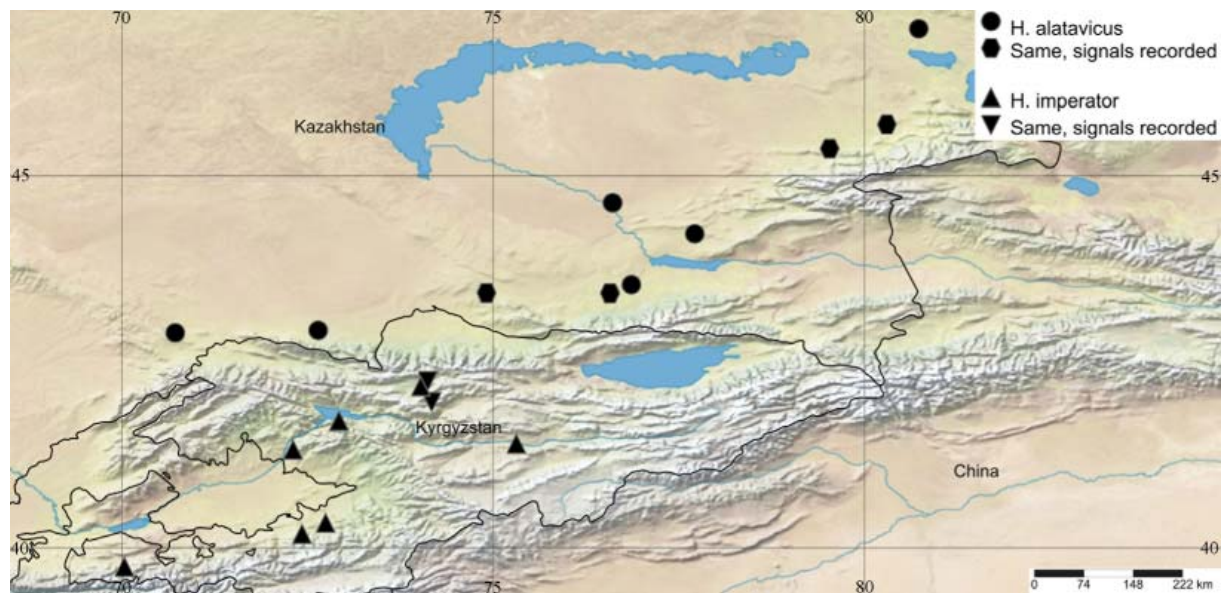


Fig. 34. Distribution map of *Handianus imperator* and *H. alatavicus* based on studied material.

Рис. 34. Карта распространения *Handianus imperator* и *H. alatavicus* по изученному материалу.

are also cases where specimens with different genitalia shapes are found in the same locality and even in the same sample [Olmí, 1976; Tishechkin, 2016]. Differences in the length and shape of processes of the aedeagus are one of the most common types of its variability. This phenomenon is described both in Deltoccephalinae (Homoptera: Cicadellidae) [Olmí, 1976; Gnezdilov, 1999] and in some other taxa [Emelyanov, Tishechkin, 2012].

Thus, the variability of the length and shape of processes of the aedeagus in *H. alatavicus*, although not a common phenomenon, is still not anything extraordinary. It is easy to see that, despite such variability, the differences between *H. imperator* and *H. alatavicus* in the shape of aedeagus are very distinct, and no intermediate forms between them were found (Figs 2–7, 9–19).

Thus, *H. imperator* and *H. alatavicus* are two morphologically different species with identical signals and host specializations. Small difference in the pulse repetition rate (17–18/s in *H. imperator* and 20–23/s in *H. alatavicus*) is apparently due to some differences in recording temperature. Signal similarity does not prevent successful intraspecific communication in these species since, based on available data, they are allopatric (Fig. 34). Still, the reasons for their allopatry are unclear. *H. imperator* was found both in the Inner Tien Shan at the altitudes of about 2000 m in harsh and rather humid climate, and in much drier and hotter climate in low mountains surrounding the Fergana Valley. Therefore, climatic conditions cannot be an obstacle to its penetration north into the low mountains of southern Kazakhstan. Both species feed on *Artemisia* spp. (probably, mainly or exclusively on species from the subgenus *Seriphidium*), which are among the most common plants in all open habitats both in Kyrgyzstan and in Kazakhstan.

A similar situation was recently described in two other *Handianus* species, *H. eurotiae* Emelyanov, 1964 and *H. futilis* Mityaev, 1975 [Tishechkin, 2023]. Both species inhabit the plains of Kazakhstan and the Lower Volga region, distinctly differ in morphology, live on the same widely distributed host plant, *Krascheninnikovia ceratoides* (L.) Gueldenst. (Chenopodiaceae) under similar climatic conditions, but produce calling signals with almost the same temporal patterns. These two species were also never collected in the same locality, although the reasons for such vicariance are unclear.

A peculiar feature of *H. alatavicus* is the presence of two types of the calling signal, short single phrases and a continuous signal that includes additional components. However, in some other leafhoppers, the most acoustically active males also sometimes produce a more complex continuous signal instead of simple single phrases. In particular, this phenomenon was described in two species of *Limotettix* (*Scleroracus*) Van Duzee, 1894 (Homoptera: Cicadellidae: Deltoccephalinae: Limotettigini) [Tishechkin, 2019]. The transformation of one type of signal into another in *Limotettix* (*Scleroracus*) occurs in the same way as in *H. alatavicus*. In an actively singing male, the gaps between phrases shorten and become constant, an additional component is added to each phrase, and thus, individual phrases merge with each other forming a single continuous signal.

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