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Review of leafhoppers of the genus *Kybos* Fieber, 1866 (Homoptera: Cicadellidae: Typhlocybinae: Empoascini) of European Russia

Обзор цикадок рода *Kybos* Fieber, 1866 (Homoptera: Cicadellidae: Typhlocybinae: Empoascini) Европейской России

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КЛЮЧЕВЫЕ СЛОВА: морфология, вибрационные призывные сигналы, кормовые растения, распространение, определительный ключ.

ABSTRACT. Illustrated descriptions of 17 species of *Kybos* from European Russia are provided, with data on distribution and host plants, and a key for their identification. Oscillograms of the male vibrational calling signals are presented for 12 species. Signal analysis showed that the taxon *matsumurai*, originally described as a subspecies of *K. rufescens* and similar to it in the shape of the abdominal apodemes, is in fact a subspecies *K. butleri matsumurai* Dworakowska, 1973, **comb.n.** The synonymy *K. verbae* Zachvatkin, 1953 = *Empoasca* (*Kybos*) *ivanovi* Logvinenko, 1980, **syn.n.** is established. Most *Kybos* species feed on several plant species from the same genus, however, quite often individual specimens were found on plants from other genera. In all such cases, conspecificity of males from different plants was confirmed by the calling signal analysis. Apparently, in some species of *Kybos*, adult specimens can feed on plants on which they cannot complete the life cycle and form a dense population.

РЕЗЮМЕ. Приведены иллюстрированные описания 17 видов *Kybos* из европейской России с данными о распространении и кормовых растениях, а также ключ для их определения. Для 12 видов представлены осциллограммы вибрационных призывных сигналов самцов. Анализ сигналов показал, что таксон *matsumurai*, первоначально описанный как подвид *K. rufescens* и сходный с ним по форме брюшных аподем, на самом деле является подвидом *K. butleri matsumurai* Dworakowska, 1973, **comb.n.** Установлена синонимия *K. verbae* Zachvatkin, 1953 = *Empoasca* (*Kybos*) *ivanovi* Logvinenko, 1980, **syn.n.** Большинство видов *Kybos* питается на нескольких видах растений из одного рода, однако нередко отдельные особи были обнаружены и на растениях из других родов. Во всех таких случаях конспецифичность самцов с разных растений подтверждается анализом призывных сигналов. По-видимому, у некоторых видов *Kybos* взрослые особи способны питаться на растениях, на которых прохождение всего жизненного цикла и формирование устойчивых популяций невозможно.

Introduction

The genus *Kybos* Fieber, 1866 (Homoptera: Cicadellidae: Typhlocybinae: Empoascini) includes 142 Holarctic species [Xu *et al.*, 2021] about 40 of which occur in the Palearctic [Dmitriev *et al*., 2022 onward]. This taxon has been variously treated by different authors either as a subgenus of *Empoasca* Walsh, 1862 [Dworakowska, 1976; Ossiannilsson, 1981] or as a separate genus [Zachvatkin, 1953a, c; Mühlethaler *et al.*, 2009]. In their recent comprehensive study, Xu *et al*. [2021] convincingly showed that *Kybos* is a separate genus.

The first review of the Palearctic species of this genus, which later became a classic, was published by Dworakowska [1976]. Illustrated keys to species of different regions of Europe were published by Ossiannilsson [1981] and Mühlethaler *et al*. [2009]. They can be used for identification of some species from European Russia, but a list of *Kybos* species of this region and a complete key for their identification do not exist. The only key to species of *Kybos* of European Russia in

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Emelyanov [1964] includes eight species, which is less than half of their actual number. Meanwhile, this genus includes many closely related and morphologically similar species, the identification of which is quite difficult. In addition, several *Kybos* taxa from the central part of European Russia were described in the articles of Zachvatkin, published after his death [Zachvatkin, 1953a, c]. Since the manuscripts were found in his archive in an unfinished form, these descriptions contain some inaccuracies and are mostly not illustrated. In this regard, the aim of this work is to provide illustrated descriptions of *Kybos* species of European Russia with data on their distribution and host plants and a key for their identification. Also, investigation of the materials on the taxa described by A.A. Zachvatkin, collected in type localities by him or his students, made it possible to verify the correctness of their interpretation.

Dworakowska [1976] noted the great importance of the male acoustic signals for interspecific reproductive isolation and, consequently, the importance of morphological characters of the sound apparatus i. e. of the male abdominal apodemes for *Kybos* species diagnostics. In this paper we also present oscillograms of the male calling signals of most species. Comparative analysis of signals made it possible to clarify the taxonomic status of a number of closely related taxa and to prove the conspecificity of populations from different geographic regions or from different host plants. In particular, the distribution of two European species in eastern Siberia was confirmed and the status of one East Palearctic taxon was elucidated.

In total, this article includes descriptions of 17 species; for 12 of them oscillograms of the male calling signals are given.

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 (before 2005), minidisk recorder Sony Walkman MZ-NH900 (2005–2016), or Roland R-05 wave/mp3 recorder (since 2017) 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 elementary 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 constant temporal pattern usually repeated with regular intervals and 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 syllables) is referred to as a **phrase**.

Digital images of male genitalia were obtained with a Micromed 3 LED M microscope equipped with a MIchrome 5 Pro camera (Tucsen). For morphological illustrations, specimens whose vibrational signals were recorded, were used as far as possible. For each species, photographs of the male abdominal apodemes, pygofer appendages, anal collar appendages, and aedeagus are provided. The shape of the styles in different species differs only slightly, if at all, so we do not give their photographs. There are few, if any, differences in coloration between species of *Kybos*. Therefore, here we provide photographs of the appearance of only several species to illustrate the main coloration types (Figs 1–6).

Figs 1–6. *Kybos* spp., dorsal habitus. 1 — *K. verbae* (topotype from the collection of Zachvatkin); 2 — *K. virgator*; 3 — *K. butleri butleri*; 4 — *K. butleri matsumurai*; 5 — *K. rufescens*; 2 — *K. abstrusa* (topotype of *K. topoli* from the collection of Zachvatkin).
Рис. 1–6. *Kybos* spp., вид сверху. 1 — *K. verbae* (топотип из коллекции Захваткина); 2 — *K. virgator*; 3 — *K. butleri butleri*; 4 — *K. butleri matsumurai*; 5 — *K. rufescens*; 2 — *K. abstrusa* (топотип *K. topoli* из коллекции Захваткина).

Data on synonymy are mainly taken from Dmitriev *et al*. [2022 onward]. Names of willow species and sections are accepted after Valyagina-Malyutina [2018].

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

Results

Species descriptions.

Kybos lindbergi (Linnavuori, 1951)
Figs 7–16, 140–142.

Kybos borealis Lindberg, 1952
Kybos betulae Zachvatkin, 1953

DESCRIPTION. Green with lighter and darker spots in fore part of body. Forewings smoky hyaline in apical parts, with darkened claval sutures, costal, and anal margins (as on Fig. 2).

Sternal apodemes of 2nd abdominal segment rather short, with outer margins strongly converging and inner margins touching each other or somewhat overlapping (Figs 7–8). 3rd tergal apodemes short (Fig. 9). Pygofer appendages narrow (Fig. 10). Anal collar appendages wide, with rounded or sharply narrowed and extended apices (Figs 11–12). Aedeagus with narrow shaft and with pair of basal processes parallel to each other and situated close to shaft in ventral view (Figs 13–16).

HOSTS. Different species of birches (*Betula* spp.).

MALE CALLING SIGNALS. Signals of one male from Moscow Oblast (Voskresensk Region, environs of Beloozerskiy Town, on *Betula pendula* Roth, 23.VII.2021, recording at 25 °C) were investigated.

Calling signal is a phrase lasting for about 0.8–1.0 s (Figs 140–142). The phrase consists of pulses following with a period of about 50–35 ms in the beginning of a phrase, 20–22 ms in its middle, and up to 60–75 in its end. In the middle of a phrase, pulses sometimes partially merge with each other, and the temporal pattern of the signal becomes irregular (Figs 141–142).

DISTRIBUTION. Eastern half of Europe, northern and eastern Kazakhstan, Siberia.

REMARKS. *K. betulae* was described based on the material from Sofrino, Moscow Oblast. We investigated, among others, specimens from Mytishchi, 25 km southwest from the type locality; they do not differ from descriptions of *K. lindbergi* in Dworakowska [1976] and Ossiannilsson [1981].

Some authors regard *K. lindbergi* the senior synonym of *K. betulicola* Wagner, 1955 (see the section on the next species).

Kybos betulicola Wagner, 1955
Figs 17–31.

DESCRIPTION. In appearance and shape of abdominal apodemes, pygofer appendages, and anal collar appendages similar to *K. lindbergi* (Figs 17–20) but differs from it by widely spaced aedeagus processes in ventral view (Figs 21–22, 25–26, 28–29).

HOSTS. According to Dworakowska [1976], Ossiannilsson [1981], and Mühlethaler *et al*. [2009], feeds on *Betula* spp. However, our specimens from Moscow Oblast were collected from *Salix triandra* L. (Figs 21, 23) and *S. caprea* L. (Figs 22, 24).

DISTRIBUTION. Western half of Europe [Dworakowska, 1976; Ossiannilsson, 1981; Mühlethaler *et al*., 2009], central part of European Russia (our data), eastern Kazakhstan [Mityaev, 1971: 123, fig. 37, *1–2*; as *K. lindbergi*], Mongolia [Dlabola, 1967], northern part of the Russian Far East [Anufriev, Emelyanov, 1988].

REMARKS. This is the most problematic taxon among European *Kybos* species.

First, Hamilton [1983: 491] synonymized *K. betulicola* under *Empoasca luda* Davidson, DeLong, 1938, but did not provide illustrations of the specimens he studied. Mühlethaler *et al*. [2009] investigated holotype of *E. luda* and also came to the conclusion that it is conspecific with *K. betulicola*; for this reason, they use the name *K. ludus* for this taxon. However, in their article, they provide the only illustration of aedeagus in ventral view (reproduced on Fig. 34). As can be seen, it fully corresponds to Figs 13–14 but differs from Figs 21–22, i. e. belongs to *K. lindbergi* but differs both from our specimens of *K. betulicola* (Figs 21–24) and from *K. betulicola* sensu Ossiannilsson [1981] (Figs 25–27) and Dworakowska [1976] (Figs 28–31). Finally, the aedeagus in the drawings in the original description (reproduced on Figs 32–33), although depicted rather schematically, is clearly not similar to the aedeagus of European specimens of *K. betulicola* [Davidson, Delong, 1938]. Due to all these contradictions, we believe that the problem requires further study and for now we use a name *K. betulicola* instead of *K. ludus*.

Second, the relationship between *K. betulicola* and *K. lindbergi* is still unclear.

Dworakowska [1976] regards *K. betulicola* West European species and suggests that at the border of its range it probably interbreeds with *K. lindbergi* because in the contact zone specimens with intermediate characters were found. Despite this, she considers these taxa to be different species. Mühlethaler *et al*. [2009] state that in Germany and Switzerland the two species are sympatric and intermediate morphological forms are frequent. However, based on the available material they conclude that *K. lindbergi* and *K. betulicola* are distinct, geographically separated species which are sympatric in a relatively restricted area in Central Europe, where hybridization occurs. On the other hand, Söderman [2007], based on the presence of specimens with intermediate morphological characters, considers these taxa to be conspecific; this point of view is also accepted in Albrecht *et al*. [2015].

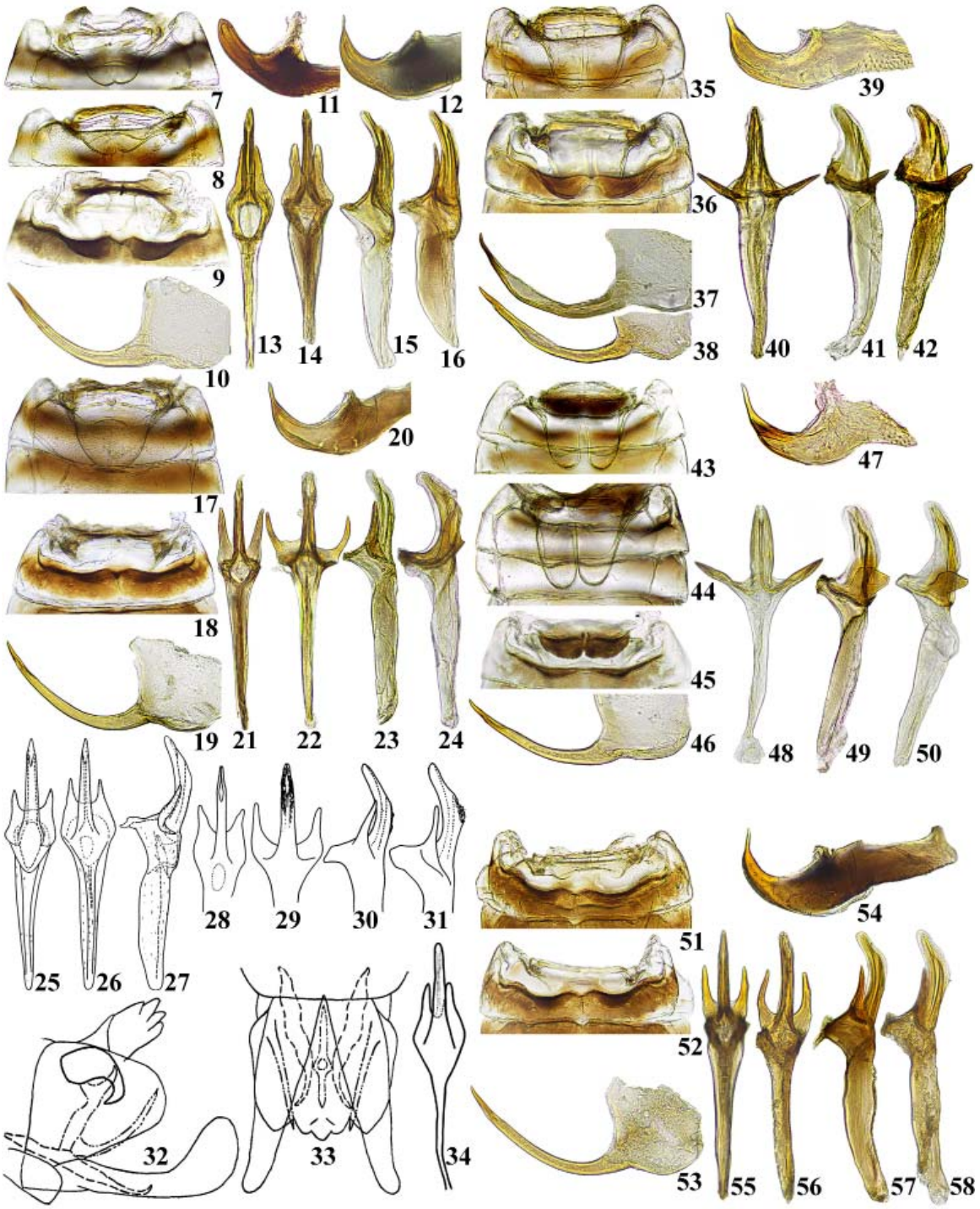
In our opinion, establishing synonymy in this case is premature. According to the data of Mityaev [1971], Dlabola [1967], and Anufriev & Emelyanov [1988], *K. betulicola* is distributed much further east than Dworakowska [1976] and Mühlethaler *et al*. [2009] believe, and is therefore sympatric with *K. lindbergi* throughout most of its range. For example, in Moscow Oblast both taxa were collected in the same locality, but on different hosts, and no males with intermediate characters were found. To finally clarify the status of *K. betulicola*, a comparative study of the signals of two morphological forms is necessary. Until then, we consider these taxa as separate species following Dworakowska [1976] and Mühlethaler *et al*. [2009].

Kybos mucronatus (Ribaut, 1933)
Figs 35–42.

Kybos cracoviensis Dworakowska, 1973

DESCRIPTION. Externally similar to previous species.

Sternal apodemes of 2nd abdominal segment rather short, separated by narrow notch, with outer margins slightly converging (Fig. 35). 3rd tergal apodemes short but distinctly visible (Fig. 36). Pygofer appendages slightly widened in middle, with elongated apical parts (Figs 37–38). Anal collar appendages wide, with sharply narrowed, extended apices (Fig. 39).



Figs 7–58. *Kybos* spp. 7–16 — *K. lindbergi*; 17–31 — *K. betulicola*; 32–34 — *K. ludus*; 35–42 — *K. mucronatus*; 43–50 — *K. verbae*; 51–58 — *K. smaragdula*. 7–8, 17, 35, 43–44, 51 — 2nd sternal abdominal apodemes, 9, 18, 36, 52 — 3rd tergal apodemes, 45 — 2nd and 3rd tergal apodemes, 10, 19, 37–38, 46, 53 — pygofer appendage, 11–12, 20, 39, 47, 54 — anal collar appendage, 13–14, 21–22, 25–26, 28–29, 34, 40, 48, 55–56 — aedeagus, ventral view, 15–16, 23–24, 27, 30–31, 41–42, 49–50, 57–58 — same, lateral view, 32 — end of male abdomen, lateral view, 33 — same, ventral view. 25–27 — after Ossiannilsson [1981], 28–31 — after Dworakowska [1976], 32–33 — after Davidson & DeLong [1938]; 34 — after Mühlethaler *et al.* [2009].

Рис. 7–58. *Kybos* spp. 7–16 — *K. lindbergi*; 17–31 — *K. betulicola*; 32–34 — *K. ludus*; 35–42 — *K. mucronatus*; 43–50 — *K. verbae*; 51–58 — *K. smaragdula*. 7–8, 17, 35, 43–44, 51 — стернальные аподемы II сегмента брюшка, 9, 18, 36, 52 — тергальные аподемы III сегмента, 45 — тергальные аподемы II и III сегментов, 10, 19, 37–38, 46, 53 — отросток доли пигофора, 11–12, 20, 39, 47, 54 — отросток анальной трубки, 13–14, 21–22, 25–26, 28–29, 34, 40, 48, 55–56 — эдеагус снизу, 15–16, 23–24, 27, 30–31, 41–42, 49–50, 57–58 — то же, сбоку, 32 — конец брюшка самца сбоку, 33 — то же, снизу. 25–27 — по: Ossiannilsson [1981], 28–31 — по: Dworakowska [1976], 32–33 — по: Davidson & DeLong [1938]; 34 — по: Mühlethaler *et al.* [2009].

Aedeagus with rather wide shaft, especially, at base and with pair of strongly diverging basal processes tapering towards apices (Figs 40–42).

HOSTS. *Alnus* spp.

DISTRIBUTION. Europe; in European Russia was recorded from Ryazan Oblast [Zachvatkin, 1953b]; we studied specimens collected by Zachvatkin and his students in Tula Oblast.

REMARK. Some authors regard *K. mucronatus* the senior synonym of *K. verbae* Zachvatkin, 1953 (see the section on the next species).

Kybos verbae Zachvatkin, 1953
Figs 1, 43–50, 143–146.

Kybos mucronatus verbae Zachvatkin, 1953
Empoasca (*Kybos*) *ivanovi* Logvinenko, 1980, **syn.n.**

DESCRIPTION. Uniformly bright green with lighter and darker spots in fore part of body (Fig. 1). Occasionally, forewings slightly smoky in apical parts.

Sternal apodemes of 2nd abdominal segment well developed, distinctly longer than their width at base, separated by narrow notch (Figs 43–44). 2nd tergal apodemes well developed, 3rd tergal apodemes very short, inconspicuous (Fig. 45). Pygofer appendages tapering evenly towards ends (Fig. 46). Anal collar appendages wide, with sharply narrowed, extended apices (Fig. 47). Aedeagus with pair of strongly diverging basal processes with expanded rectangular or widely rounded apices (Figs 48–50).

HOSTS. We collected this species and recorded signals of males from *Salix acutifolia* Willd.; this plant was also indicated as a host by Zachvatkin [1953a]. However, in Zachvatkin's materials there are also specimens from *S. purpurea* L. (obviously, closely related *S. vinogradovii* A. Skvorts. is meant, since *S. purpurea* does not grow in the central part of European Russia); still, in the original description *S. purpurea* was not mentioned as a host. Also, in Moscow Oblast we once collected several specimens from *S. viminalis* L. The ability of *K. verbae* to feed on many willow species is confirmed by records from Western Europe, outside the range of *S. acutifolia*.

MALE CALLING SIGNALS. Signals of two males from Moscow Oblast (Serpukhov Region, the bank of the Oka River in the environs of Luzhki Village, on *S. acutifolia*, 10.VI.2007, recording at 25–26 °C) were investigated.

Calling signal is a phrase lasting for about 5–10 s and consisting of short syllables (Figs 143–144). At the beginning of a phrase, syllables have lower amplitude and are variable in shape; their repetition period can vary widely. After 1–3 s from the beginning of a phrase, the amplitude of syllables increases and becomes constant; their temporal pattern and the repetition period also become less variable (Figs 145–146). Normally, syllables in the main part of a phrase follow with a period of 400–700 ms. Pulse repetition period in syllable is 18–26 ms, the gap between the last two pulses usually is distinctly longer and reaches 30–50 ms.

DISTRIBUTION. France [Della Giustina, 1989], Latvia, Poland [Dworakowska, 1976], European Russia.

REMARKS. Was described based on the materials from the basin of the Oka River in Moscow and Ryazan Oblasts. The species identification is based on the investigation of the population from Moscow Oblast, the Oka River floodplain in the vicinity of Luzhki Village, living on *S. acutifolia* and of specimens collected in this locality by Zachvatkin and his students.

Some authors consider *K. verbae* a junior synonym of *K. mucronatus*. However, *K. verbae* differs from it by brighter coloration, well-developed 2nd tergal apodemes, which are absent in other species of the genus, shorter apical parts of pygofer appendages (very long in *K. mucronatus*), and by aedeagus processes widened at the ends (narrow and usually pointed in *K. mucronatus*). In addition, in the type locality, *K. verbae* forms dense populations on *S. acutifolia*, in which we found both adults and nymphs. This indicates that *S. acutifolia* is indeed a host for this species, whereas *K. mucronatus* feeds on *Alnus* spp.

The very detailed illustrated description of *Empoasca* (*Kybos*) *ivanovi* Logvinenko, 1980 leaves no doubt that this taxon is a junior synonym of *K. verbae*. This is primarily indicated by the shape of the basal processes of aedeagus with widely rounded angular apices [Logvinenko, 1980: 87, fig. 1, *4–6*] and by the presence of well-developed 2nd tergal apodemes in combination with very short 3rd tergal apodemes [Logvinenko, 1980: 88, fig. 2, *6*].

Kybos smaragdula (Fallén, 1806)
Figs 51–58, 147–150.

Typhlocyba chloapala Walker, 1851
Jassus longeciliatus Snellen van Vollenhoven, 1862
Eupteryx viridipes Curtis, 1831
Eupteryx viridipes Curtis, 1837

DESCRIPTION. Green with lighter and darker spots in fore part of body. Forewings smoky hyaline in apical parts, with darkened claval sutures, costal, and anal margins (as on Fig. 2).

Sternal apodemes of 2nd abdominal segment weakly developed, almost indistinguishable (Fig. 51). 3rd tergal apodemes very short (Fig. 52). Pygofer appendages tapering evenly towards ends (Fig. 53). Anal collar appendages wide, with sharply narrowed, extended apices (Fig. 54). Aedeagus with narrow shaft and pair of parallel or slightly converging basal processes (Figs 55–58).

HOSTS. *Alnus* spp.; in Moscow Oblast was also collected from *Salix triandra* L. Conspecificity of males from different hosts was confirmed by the calling signal analysis.

MALE CALLING SIGNALS. Signals of males from the following localities were investigated.

1. Moscow Oblast, Serpukhov Region, Pushchino-na-Oke Town, on *Alnus incana* L., 12.VI.2000, signals of four males recorded at 21 °C (Figs 147, 149).

2. Moscow Oblast, Serpukhov Region, the bank of the Oka River in the environs of Luzhki Village, on *S. triandra*, 10.VI.1989, signals of one male recorded at 25 °C (Figs 148, 150).

Calling signal is a phrase lasting for 1.8–2.1 s (Figs 147–148). It consists of pulses following with a period from 17–18 to 22–24 ms; the repetition period of pulses during the phrase, as a rule, slightly decreases, and the amplitude changes irregularly (Figs 149–150). Sometimes at the end of the phrase there are 5–7 pulses with a significantly lower amplitude, following with a period of 9–10 ms (Fig. 150).

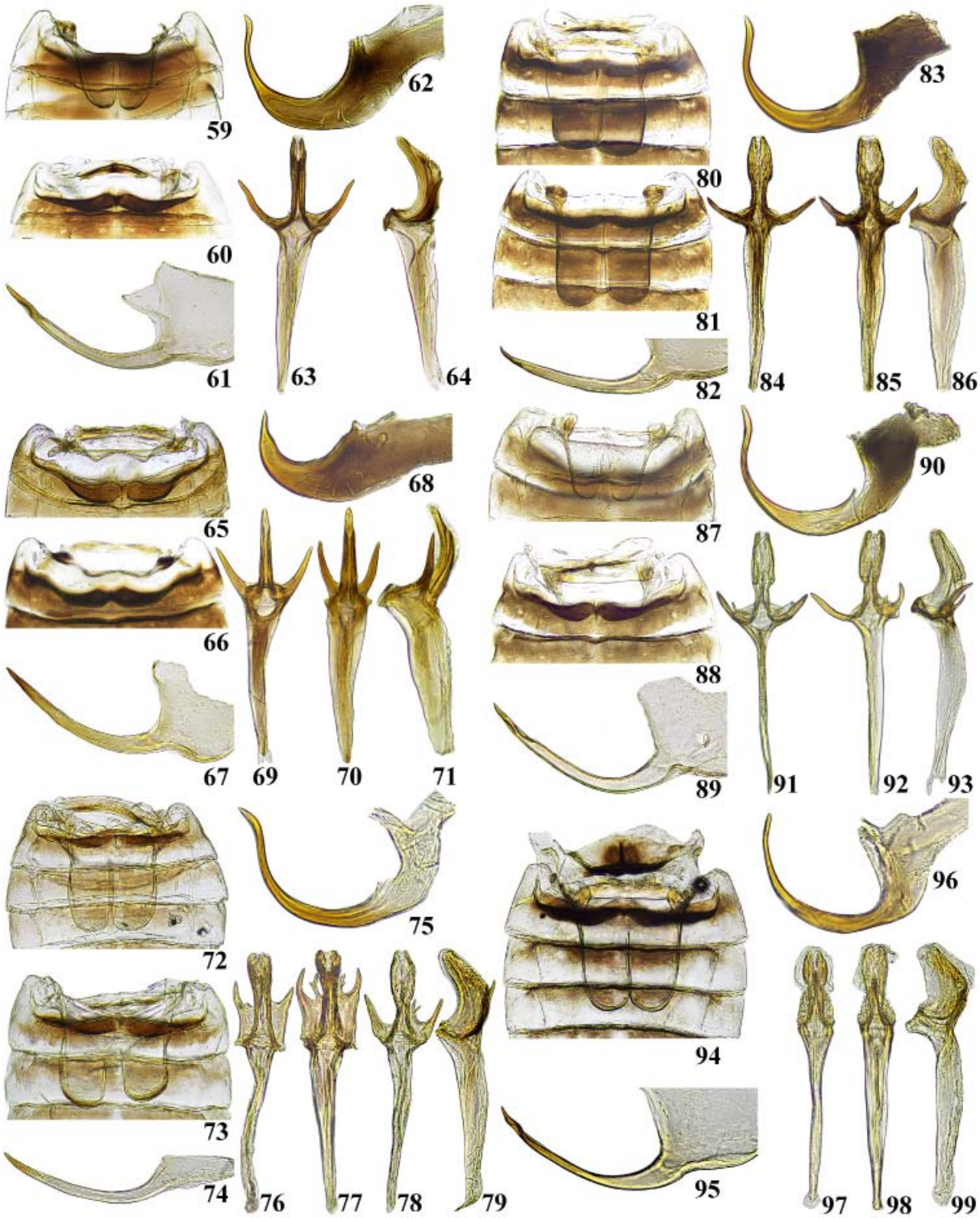
DISTRIBUTION. Europe, Western Siberia, northern Kazakhstan.

Kybos strigilifer (Ossiannilsson, 1941)
Figs 59–64, 151–154.

Kybos altaicus Mityaev, 1963
Empoasca paraltaica Orosz, 1996
Empoasca perplexa Ribaut, 1952

DESCRIPTION. Externally similar to previous species.

Sternal apodemes of 2nd abdominal segment well developed, separated by narrow notch, with outer margins slightly converging (Fig. 59). 3rd tergal apodemes short but distinctly



Figs 59–99. *Kybos* spp. 59–64 — *K. strigilifer*; 65–71 — *K. strobli*; 72–79 — *K. albilacustris*; 80–86 — *K. virgator*; 87–93 — *K. volgensis*; 94–99 — *K. limpidus*. 59, 87 — 2nd sternal abdominal apodemes, 60, 88 — 3rd tergal apodemes, 65–66, 72–73, 80–81, 94 — 2nd sternal and 3rd tergal apodemes, 61, 67, 74, 82, 89, 95 — pygofer appendage, 62, 68, 75, 83, 90, 96 — anal collar appendage, 63, 69–70, 76–78, 84–85, 91–92, 97–98 — aedeagus, ventral view, 64, 71, 79, 86, 93, 99 — same, lateral view.

Рис. 59–99. *Kybos* spp. 59–64 — *K. strigilifer*; 65–71 — *K. strobli*; 72–79 — *K. albilacustris*; 80–86 — *K. virgator*; 87–93 — *K. volgensis*; 94–99 — *K. limpidus*. 59, 87 — стернальные аподемы II сегмента брюшка, 60, 88 — тергальные аподемы III сегмента, 65–66, 72–73, 80–81, 94 — стернальные аподемы II сегмента и тергальные аподемы III сегмента, 61, 67, 74, 82, 89, 95 — отросток доли пигофора, 62, 68, 75, 83, 90, 96 — отросток анальной трубки, 63, 69–70, 76–78, 84–85, 91–92, 97–98 — эдеагус снизу, 64, 71, 79, 86, 93, 99 — то же, сбоку.

visible (Fig. 60). Pygofer appendages tapering evenly towards ends (Fig. 61). Anal collar appendages wide, with sharply narrowed, extended, occasionally, rather long apices (Fig. 62). Aedeagus with narrow shaft and pair of strongly diverging basal processes (Figs 63–64).

HOSTS. Willows from the section Cinerella (*S. caprea* L., *S. cinerea* L., *S. starkeana* Willd.); also, was recorded from *S. myrsinifolia* Salisb. (section Nigricantes).

MALE CALLING SIGNALS. Signals of males from the following localities were investigated.

1. Moscow Oblast, Serpukhov Region, Pushchino-na-Oke Town, on *S. starkeana*, 15.VI.2000, signals of two males recorded at 22–23 °C; same locality, on *S. caprea*, 9.VI.2007, signals of one male recorded at 26 °C (Figs 151, 153).

2. Irkutsk Oblast, the Uk River at the confluence with the Uda River (ca 12 km north-northwest of Nizhneudinsk Town), on *S. caprea*, 1.VII.2003, signals of one male recorded at 24–27 °C (Figs 152, 154).

Calling signal is a phrase lasting for 2.3–3.5 s and usually consisting of two parts (Figs 151–154). The first part is a sequence of syllables including two partially merged pulses each and following with a period of 37–49 ms. The second part is a short component with lower amplitude and indistinguishable pulses; in some phrases it is absent (the first phrase on Fig. 151). The duration of a phrase does not depend on the presence of a second part; moreover, phrases that include only a sequence of syllables sometimes are longer than phrases that include both parts.

Signals of males from Moscow Oblast (Figs 151, 153) and Siberia (Figs 152, 154) are similar.

DISTRIBUTION. Europe including European Russia [Dworakowska, 1976; Mühlethaler *et al.*, 2009], Siberia, Irkutsk Oblast (new record).

Kybos strobli (Wagner, 1949)
Figs 65–71

DESCRIPTION. Externally similar to previous species.

Sternal apodemes of 2nd abdominal segment weakly developed, almost indistinguishable, 3rd tergal apodemes very short (Figs 65–66). Pygofer appendages tapering evenly towards ends (Fig. 67). Anal collar appendages wide, with sharply narrowed, extended apices (Fig. 68). Aedeagus with narrow shaft and pair of diverging basal processes (Figs 69–71).

HOST. *Alnus incana* both in Western Europe and in European Russia.

DISTRIBUTION. Europe, mainly in mountain regions (Alps, Carpathians) [Dworakowska, 1976; Mühlethaler *et al*., 2009], Karelia [Anufriev, Humala, 2015], the central part of European Russia, Tula Oblast (new record).

Kybos albilacustris Tishechkin, 2002
Figs 72–79, 155–160

DESCRIPTION. Bright green with lighter and darker spots in fore part of body. Forewings smoky hyaline in apical parts, usually, with darkened claval sutures, costal, and anal margins.

Sternal apodemes of 2nd abdominal segment long and wide, parallel-sided, touching each other with inner margins or separated by narrow notch, 3rd tergal apodemes very short (Figs 72–73). Pygofer appendages tapering evenly towards ends (Fig. 74). Anal collar appendages narrow, falcate (Fig. 75). Aedeagus with rather wide shaft and pair of moderately diverging or almost parallel basal processes usually having well developed common base with asymmetrical additional small appendages (Figs 76–79).

HOSTS. Willows from the section Salicaster: *Salix pentandra* L. in European Russia, *S. pseudopentandra* B. Flod. in Eastern Siberia.

MALE CALLING SIGNALS. Signals of males from the following localities were investigated.

1. Moscow Oblast, Voskresensk Region, environs of Beloozerskiy Town, on *S. pentandra*, 2–5.VII.1992, signals of six males recorded at 23–25 °C; same locality and host, 17.VIII.2001, signals of one male recorded at 26 °C (Figs 155–156, 158–159).

2. Irkutsk Oblast, the Buguldeika River ca 2 km upstream from the Kosaya Steppe Village (ca 22 km west-northwest of Elantsy), on *S. pseudopentandra*, 12.VII.2003, signals of one male recorded at 27 °C (Figs 157, 160).

Calling signal is a phrase lasting for 6–15 s and consisting of two parts (Figs 155–157). The duration and temporal pattern of the first part vary greatly. It consists of one or several successions of pulses or short syllables including low-amplitude vibrations and one high-amplitude pulse each (Figs 158–160). Their repetition period can vary from 30–70 ms in the beginning to 150–200 ms in the end. Sometimes pulses are grouped in two or three; in this case duration of gaps between some pulses is 15–20 ms (Fig. 160).

Duration of the second part is more constant and averages 2 s; it is a monotonous vibrations and the pulses in it are indistinguishable.

DISTRIBUTION. The central part of European Russia, Siberia, Irkutsk Oblast (new record). Conspecificity of males from European Russia and Siberia was confirmed by the calling signal analysis.

REMARK. Investigation of the male calling signals of *K. albilacustris* confirms that this taxon is a good species. Apparently, it is widespread in Europe and Siberia, but was confused with *K. virgator*.

Kybos virgator (Ribaut, 1933)
Figs 2, 80–86, 161–168.

Empoasca virgator var. *saageri* Wagner, 1935

DESCRIPTION. Green with lighter and darker spots in fore part of body. Forewings smoky hyaline in apical parts, with darkened claval sutures, costal, and anal margins (Fig. 2).

In shape of abdominal apodemes, pygofer appendages, and anal collar appendages similar to *K. albilacustris* (Figs 80–83), but differs from it by strongly diverging basal processes of aedeagus (Figs 84–86).

HOSTS. Different willow species, occasionally, also *Alnus* [Dworakowska, 1976]. In Moscow Oblast was collected mainly on *Salix euxina* I.V. Belyaeva (= *S. fragilis* auct.; see Valyagina-Malyutina, 2018) and, in much smaller numbers, on ornamental *S. purpurea* cultivar *nana*; also, one population was found on cultivated *Populus nigra* var. *italica* Münchh. (= *P. pyramidalis* Salisb.). Conspecificity of males from *S. euxina*, *S. purpurea*, and *P. nigra* var. *italica* was confirmed by calling signal analysis.

MALE CALLING SIGNALS. Signals of males from the following localities were investigated.

1. Moscow Oblast, Serpukhov Region, the bank of the Oka River in the environs of Luzhki Village, on *S. euxina*, 14.VI.2000, signals of two males recorded at 23–24 °C.

2. Moscow Oblast, Mytishchi Town, on *S. euxina*, 30.VII.2021, signals of two males recorded at 25 °C; same locality and date, on ornamental *S. purpurea* cultivar *nana*, signals of one male recorded at 25 °C; same locality, 21.VI.2023, on cultivated *P. nigra* var. *italica*, signals of two males recorded at 23 °C.

Calling signal is a phrase lasting for about 5–15 s and consisting of short syllables following with a period from 300–400 up to 600–900 ms (Figs 161–164). Usually, each syllable consists of a sharp amplitude peak and a prolonged monotonous component (Figs 165–166). The shape and amplitude ratio of different components of a syllable are very variable, and the amplitude peak at the beginning of a syllable can be absent (Fig. 167); syllables of different shapes can be present in the same phrase (Fig. 168).

DISTRIBUTION. Europe including European Russia.

Kybos volgensis Vilbaste, 1961
Figs 87–93, 169–171.

DESCRIPTION. In appearance and shape of male genitalia and 3rd tergal apodemes similar to *K. virgator* (Figs 88–93) but differs from it by shorter and narrower 2nd sternal apodemes with outer margins converging (Fig. 87).

HOSTS. In Moscow Oblast was collected from *Salix alba* L., in the southern Urals, Orenburg Oblast, in addition to *S. alba*, was collected from *S. viminalis*. Recorded from *S. pentandra* by Ossiannilsson [1981] and from *S.* cf. *pentandra* by Mühlethaler *et al*. [2009].

MALE CALLING SIGNALS. Signals of three males from Moscow Oblast (Voskresensk Region, environs of Beloozerskiy Town, the bank of the Moskva River, on *S. alba*, 23.VII.2018, recording at 22–24 °C) were investigated.

Calling signal is a phrase lasting for about 1.6–2.8 s (Fig. 169). It begins with a sequence of pulses, which soon transform into two-pulse syllables following with a period of 45–60 ms (Figs 170–171). Occasionally a phrase consists only of single pulses.

DISTRIBUTION. Center and south of European Russia southwards to Northwest Caucasus [Gnezdilov, 2000] and eastwards to southern Urals (our data); Czech Republic [Mühlethaler *et al*., 2009]. Mühlethaler *et al*. [2009] believe that most records of *K. volgensis* from Western Europe, including record from Sweden in Ossiannilsson [1981], refer to the juvenile form of *K. virgator* with underdeveloped apodemes. However, the finding of this species in Moscow Oblast confirmed by signal recordings indicates that it is widespread in European Russia.

REMARK. Morphological differences between *K. volgensis* and *K. virgator* are quite small, but distinct differences in the calling signal patterns indicate that these taxa are good species.

Kybos limpidus (Wagner, 1955)
Figs 94–99, 172–175.

DESCRIPTION. Bright green with lighter and darker spots in fore part of body. Forewings smoky hyaline in apical parts, with darkened costal and anal margins and, occasionally, claval sutures.

Sternal apodemes of 2nd abdominal segment long and wide, parallel-sided, touching each other with inner margins, 3rd tergal apodemes very short (Fig. 94). Pygofer appendages tapering evenly towards ends (Fig. 95). Anal collar appendages narrow, falcate (Fig. 96). Aedeagus without lateral processes, with wide shaft in lateral view (Figs 97–99).

HOSTS. *Salix viminalis*; Mühlethaler *et al*. [2009] also list *S. triandra* and possibly *S. pentandra* as hosts of this species.

MALE CALLING SIGNALS. Signals of males from the following localities were investigated.

1. Moscow Oblast, Serpukhov Region, the bank of the Oka River in the environs of Luzhki Village, on *S. viminalis*, 11.VI.1989, signals of three males recorded at 26 °C.

2. Moscow Oblast, Voskresensk Region, environs of Beloozerskiy Town, the bank of the Moskva River, on *S. viminalis*, 9.VIII.2021, signals of six males recorded at 30–31 °C.

Calling signal is a phrase lasting from 2 to 15–16 s in our recordings. It usually begins with a short variable component, followed by a prolonged sequence of discrete pulses (Figs 172–173, 175); sometimes the short initial component is absent (Fig. 174). The pulse repetition period in the main part of a phrase varies from 85–100 to 170–190 ms, sometimes it increases slightly towards its end.

DISTRIBUTION. Europe including European Russia.

REMARK. Vilbaste [1968] erroneously synonymized *K. limpidus* under *K. oshanini* Zachvatkin, 1953, the original description of which is not illustrated, and therefore its identification at that time caused great difficulties. These species distinctly differ in the shape of the male abdominal apodemes (cf. Figs 94 and 130) and in the calling signal temporal patterns (cf. Figs 172–175 and 199–202).

Kybos butleri (Edwards, 1908)
Figs 3–4, 100–114, 176–183.

Kybos oshanini occidentalis Zachvatkin, 1953
Kybos rufescens matsumurai Dworakowska, 1973, **syn.n.**
Kybos butleri matsumurai Dworakowska, 1973, **comb.n.**

DESCRIPTION. Green with lighter and darker spots in fore part of body. Forewings smoky hyaline in apical parts, with widely darkened anal margins and, sometimes, with costal veins darkened in basal part (Figs 3–4).

In European subspecies, *K. butleri butleri*, sternal apodemes of 2nd abdominal segment long and wide, parallel-sided, touching each other with inner margins (Fig. 100), 3rd tergal apodemes well developed, of approximately same length and width, separated by very wide notch (Fig. 101). In East Palearctic subspecies, *K. butleri matsumurai* **comb.n.**, sternal apodemes of 2nd abdominal segment much shorter and narrower, with slightly converging outer margins (Fig. 106), 3rd tergal apodemes weakly developed, inconspicuous (Fig. 107). In both subspecies, pygofer appendages tapering evenly towards ends (Figs 102, 108–109), anal collar appendages narrow, falcate (Figs 103, 110), aedeagus without lateral processes, with wide shaft in lateral view (Figs 104–105, 111–114).

HOSTS. Different willow species. Males whose signals were recorded, were collected from *S. triandra* and *S. starkeana* in Moscow Oblast and from *S. kochiana* Trautv. in Buryatia. Dworakowska [1976], Ossiannilsson [1981], and Mühlethaler *et al*. [2009] list *S. aurita* L., *S. cinerea*, *S. repens* L., *S. triandra*, *S. caprea*, and S. *myrsinifolia* as hosts.

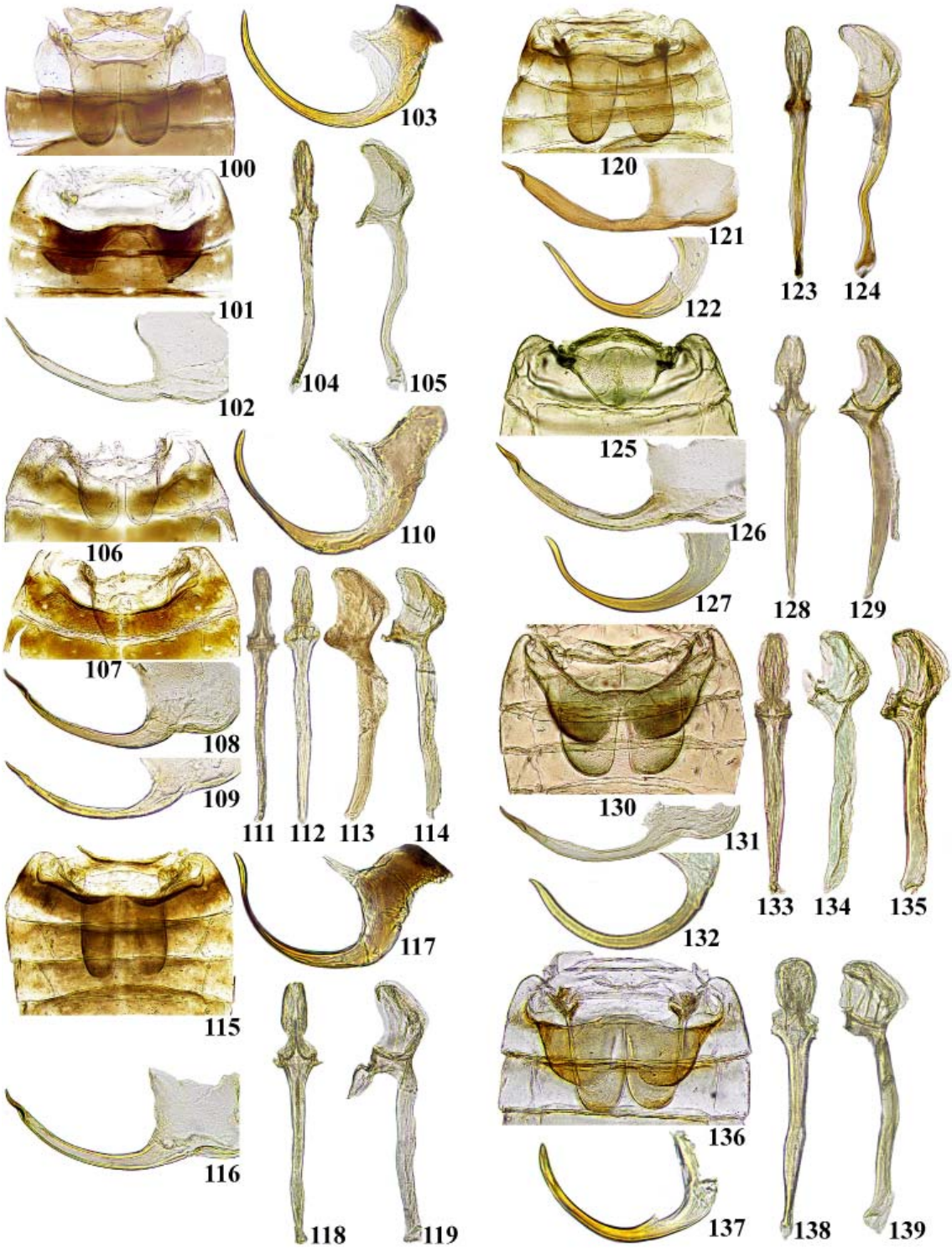
MALE CALLING SIGNALS. Signals of males from the following localities were investigated.

1. Moscow Oblast, Serpukhov Region, Pushchino-na-Oke Town, on *S. triandra*, 13.VI.2000, signals of two males recorded at 21 °C (Figs 176, 178).

2. Moscow Oblast, Voskresensk Region, environs of Beloozerskiy Town, on *S. starkeana*, 30.VI.1993, signals of one male recorded at 21–22 °C (Figs 177, 179–180).

3. Buryatia, the Irkut River valley, environs of Mondy Village, on *S. kochiana*, 4.VII.2007, signals of four males recorded at 26–27 °C (Figs 181–183).

Calling signal is a phrase lasting for 5–15 s (Figs 176–177, 181). It is formed by syllables, each consisting of a monotonous component, the pulses in which are partially merged, and several pulses separated by distinct gaps. Sometimes the syllables



Figs 100–139. *Kybos* spp. 100–105 — *K. butleri butleri*; 106–114 — *K. butleri matsumurai*; 115–119 — *K. rufescens*; 120–124 — *K. populi*; 125–129 — *K. abstrusus*; 130–135 — *K. oshanini*; 136–139 — *K. sordidulus*. 100, 106, 125 — 2nd sternal abdominal apodemes, 101, 107 — 3rd tergal apodemes, 115, 120, 130, 136 — 2nd sternal and 3rd tergal apodemes, 102, 108–109, 116, 121, 126, 131 — pygofer appendage, 103, 110, 117, 122, 127, 132, 137 — anal collar appendage, 104, 111–112, 118, 123, 128, 133, 138 — aedeagus, ventral view, 105, 113–114, 119, 124, 129, 134–135, 139 — same, lateral view.

Рис. 100–139. *Kybos* spp. 100–105 — *K. butleri butleri*; 106–114 — *K. butleri matsumurai*; 115–119 — *K. rufescens*; 120–124 — *K. populi*; 125–129 — *K. abstrusus*; 130–135 — *K. oshanini*; 136–139 — *K. sordidulus*. 100, 106, 125 — стернальные аподемы II сегмента брюшка, 101, 107 — тергальные аподемы III сегмента, 115, 120, 130, 136 — стернальные аподемы II сегмента и тергальные аподемы III сегмента, 102, 108–109, 116, 121, 126, 131 — отросток доли пигофора, 103, 110, 117, 122, 127, 132, 137 — отросток анальной трубки, 104, 111–112, 118, 123, 128, 133, 138 — эдеагус снизу, 105, 113–114, 119, 124, 129, 134–135, 139 — то же, сбоку.

are separated by long gaps (Figs 176, 178), sometimes, on the contrary, they follow one another without gaps (Figs 177, the first half of the oscillogram, 179–183); both variants can be observed in the signals of the same male (Fig. 177). Syllable repetition period varies from about 300–400 to 700–800 ms. In males from Moscow Oblast, the number of pulses in syllables is 2–5 (Figs 178–180), in males from Buryatia it is 5–6; in addition, the first part of the syllable has a more regular pattern (Figs 182–183). Nevertheless, the general temporal pattern of signals in both subspecies is very similar (cf. Figs 176–180 and 181–183), which indicates that they belong to the same species.

DISTRIBUTION. Transpalearctic.

REMARKS. Despite the similar shape of the 2nd sternal apodemes and male genitalia, this species differs from *K. oshanini* in the widely darkened anal margins of the forewings, the shape of the 3rd tergal apodemes (well developed, separated by wide notch in *K. butleri butleri* or almost reduced in *K. butleri matsumurai* vs. well developed, separated by narrow notch in *K. oshanini*), and the temporal pattern of the male calling signals.

K. butleri matsumurai, **comb.n.** was originally described as a subspecies of *K. rufescens* Melichar, 1896 because in the shape of the abdominal apodemes it is more similar to it than to *K. butleri* (in the shape of the male genitalia these species are indistinguishable). However, investigation of the male calling signals clearly indicates that the East Palearctic *Kybos* taxon with wide dark stripes along the anal margins of the forewings belongs to *K. butleri* (cf. Figs 176–180, 181–183, and 184–187).

Kybos rufescens Melichar, 1896
Figs 5, 115–119, 184–187.

Kybos smaragdula rufescens Melichar, 1896

DESCRIPTION. Green with lighter and darker spots in fore part of body, coloration is slightly brighter than in *K. butleri*. Forewings smoky hyaline in apical parts, with widely darkened anal margins and, sometimes, with costal veins darkened in basal part (Fig. 5).

Sternal apodemes of 2nd abdominal segment long and narrow, parallel-sided, separated by narrow notch, 3rd tergal apodemes weakly developed, very short (Fig. 115). In the shape of male genitalia similar to *K. butleri* (Figs 116–119).

HOSTS. Willows from the section Helix. In Moscow Oblast was collected only from ornamental *S. purpurea* cultivar *nana*, in the southern part of European Russia lives on *S. vinogradovii*. In Europe the main host of *K. rufescens* is *S. purpurea*, although it can sometimes breed on *Alnus glutinosa* (L.) Gaertn. [Dworakowska, 1976; Ossiannilsson, 1981].

MALE CALLING SIGNALS. Signals of males from the following localities were investigated.

1. Moscow Oblast, Mytishchi Town, on ornamental *S. purpurea* cultivar *nana*, 30.VII.2021, signals of six males recorded at 25 °C.

2. Moscow Oblast, Voskresensk Region, environs of Beloozerskiy Town, on ornamental *S. purpurea* cultivar *nana*, 23.VII.2024, signals of one male recorded at 24 °C.

Calling signal is a succession of pulses lasting from 4 to 15 s in our recordings (Figs 184–187). Pulse repetition period varies from 150 to 300 ms.

DISTRIBUTION. Europe including the central and southern parts of European Russia. All records from the eastern half of the Palearctic require verification, since at least some of them actually refer to *K. butleri matsumurai*.

Kybos populi (Edwards, 1908)
Figs 120–124, 188–198.

Kybos aurantiaca Dlabola, 1951
Kybos populi tremulae Zachvatkin, 1953
Kybos zaisanensis Mityaev, 1968

DESCRIPTION. Bright green with lighter and darker spots in fore part of body. Forewings smoky hyaline in apical parts, usually with darkened costal and anal margins and, occasionally, claval sutures (as on Fig. 2).

Sternal apodemes of 2nd abdominal segment long and wide, parallel-sided, touching each other with inner margins or somewhat diverging, 3rd tergal apodemes very short, inconspicuous (Fig. 120). Pygofer appendages with distinct expansions in apical halves (Fig. 121). Anal collar appendages narrow, falcate (Fig. 122). Aedeagus without lateral processes, with wide shaft in lateral view (Figs 123–124).

HOSTS. Different poplar species [Dworakowska, 1976; Ossiannilsson, 1981; Mühlethaler *et al*., 2009]. In Moscow Oblast was collected from *Populus alba* L., *P. tremula* L., and *S. caprea*; conspecificity of males from different hosts was confirmed by calling signal analysis.

MALE CALLING SIGNALS. Signals of males from the following localities were investigated.

1. Moscow Oblast, Voskresensk Region, environs of Beloozerskiy Town, on *S. caprea*, 21.VI.1993, signals of one male recorded at 20 °C; same locality, on *P. alba*, 23.VII.2021, signals of two males recorded at 25 °C.

2. Moscow Oblast, Serpukhov Region, Pushchino-na-Oke Town, on *P. tremula*, 9.VI.2007, signals of two males recorded at 26 °C.

Calling signal is a short succession of pulses lasting for 2–6 s in our recordings (Figs 188–191). Pulse repetition period is 300–600 ms (Figs 192–198). As a rule, the pulse begins with a sharp amplitude peak, after which its amplitude gradually decreases. Sometimes the pulses contain amplitude modulations, thus they are transformed into short syllables (Fig. 196). Such variability of the pulse shape can be observed in different signals of the same male (Figs 196–198).

DISTRIBUTION. Transpalearctic: Europe including European Russia [Dworakowska, 1976; Ossiannilsson, 1981], Kazakhstan [Mityaev, 1971], northern Kyrgyzstan [Tishechkin, 2024], Siberia, northern part of the Russian Far East [Anufriev, Emelyanov, 1988].

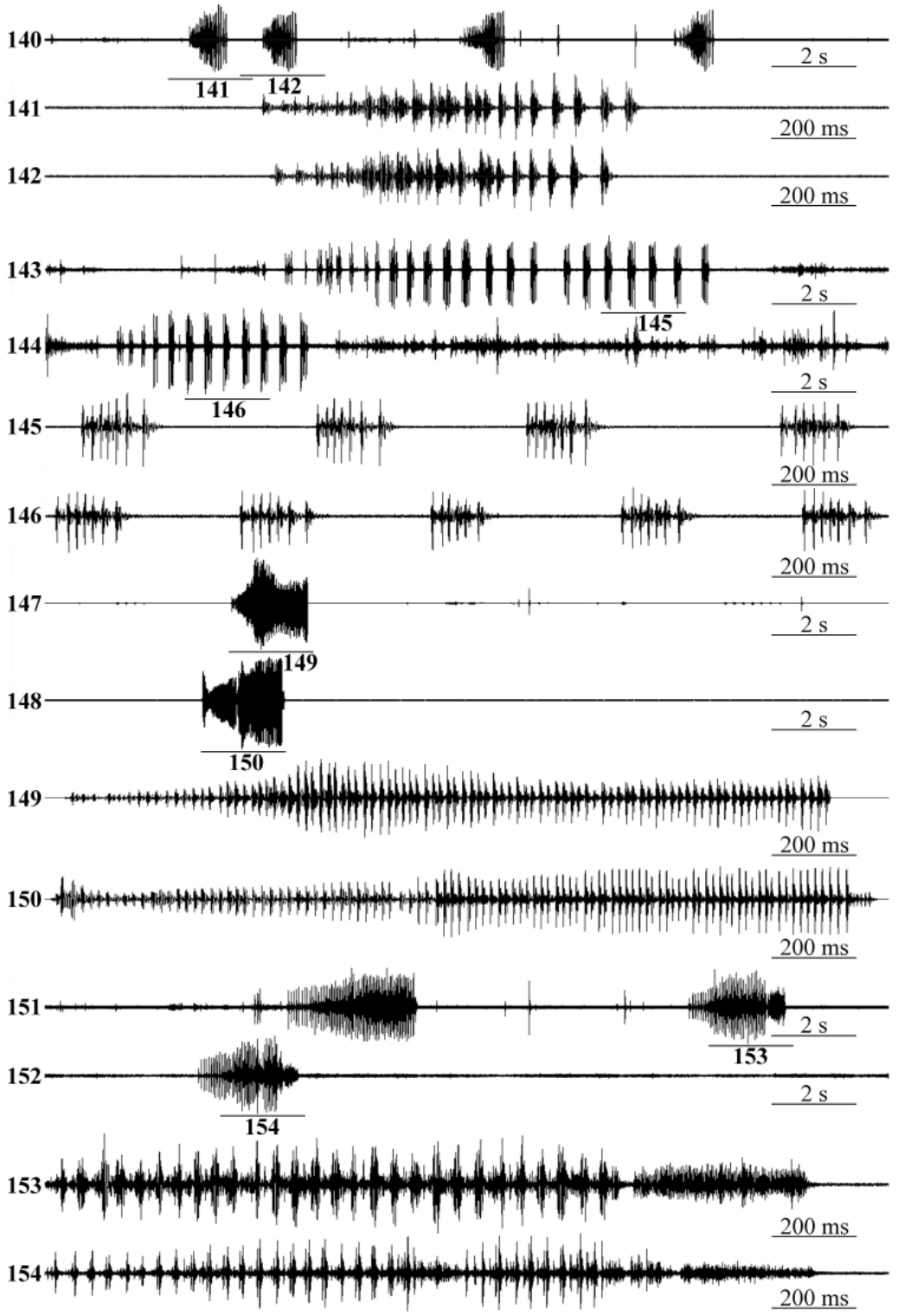
REMARK. *K. populi tremulae* was described based on the materials collected from *P. tremula* in different regions of Moscow Oblast, type locality is environs of Sofrino town. The signals of males from Moscow Oblast collected from different hosts do not have any significant differences (cf. Figs 192–193, 194–195, and 196–198), which confirms the conspecificity of taxa from *P. tremula* and other plants.

Kybos abstrusus (Linnavuori, 1950)
Figs 6, 125–129.

Kybos topoli Zachvatkin, 1953
Empoasca taunica Wagner, 1955

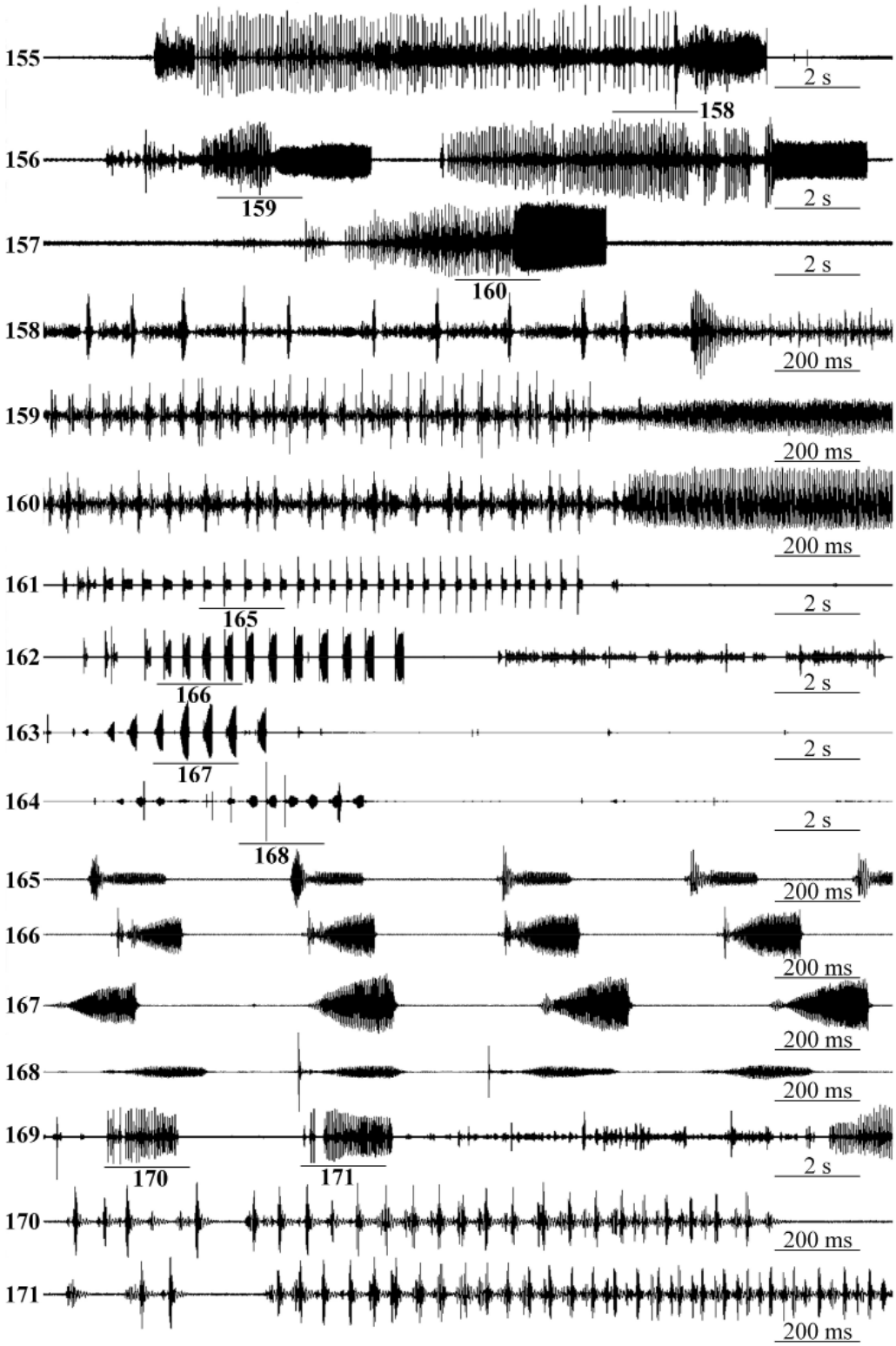
DESCRIPTION. Bright green with lighter and darker spots in fore part of body. Forewings smoky hyaline in apical parts, occasionally, with darkened costal and anal margins (Fig. 6).

Sternal apodemes of 2nd abdominal segment rather short, separated by narrow notch or somewhat overlapping, with outer margins converging, 3rd tergal apodemes weakly developed,



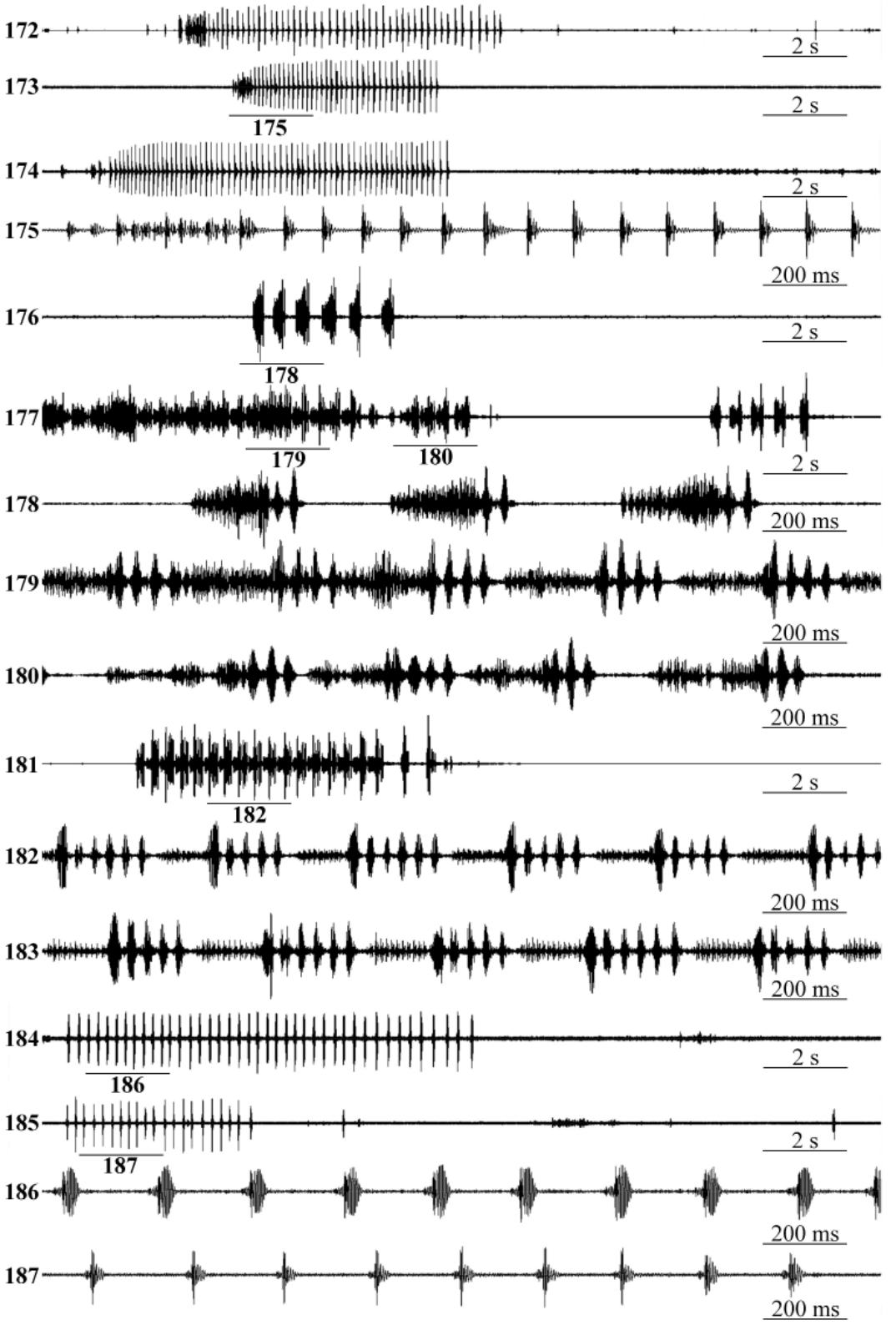
Figs 140–154. *Kybos* spp., calling signal oscillograms. 140–142 — *K. lindbergi*; 143–146 — *K. verbae*; 147–150 — *K. smaragdula* (147, 149 — male from *Alnus incana*, 148, 150 — male from *Salix triandra*); 151–154 — *K. strigilifer* (151, 153 — male from Moscow Oblast, 152, 154 — male from Irkutsk Oblast). Faster oscillograms of the parts of signals indicated as "141–142, 145–146, 149–150, and 153–154" are given under the same numbers.

Рис. 140–154. *Kybos* spp., осциллограммы призывных сигналов. 140–142 — *K. lindbergi*; 143–146 — *K. verbae*; 147–150 — *K. smaragdula* (147, 149 — самец с *Alnus incana*, 148, 150 — самец с *Salix triandra*); 151–154 — *K. strigilifer* (151, 153 — самец из Московской обл., 152, 154 — самец из Иркутской обл.). Фрагменты сигналов, помеченные цифрами "141–142, 145–146, 149–150 и 153–154", представлены на осциллограммах под соответствующими номерами.



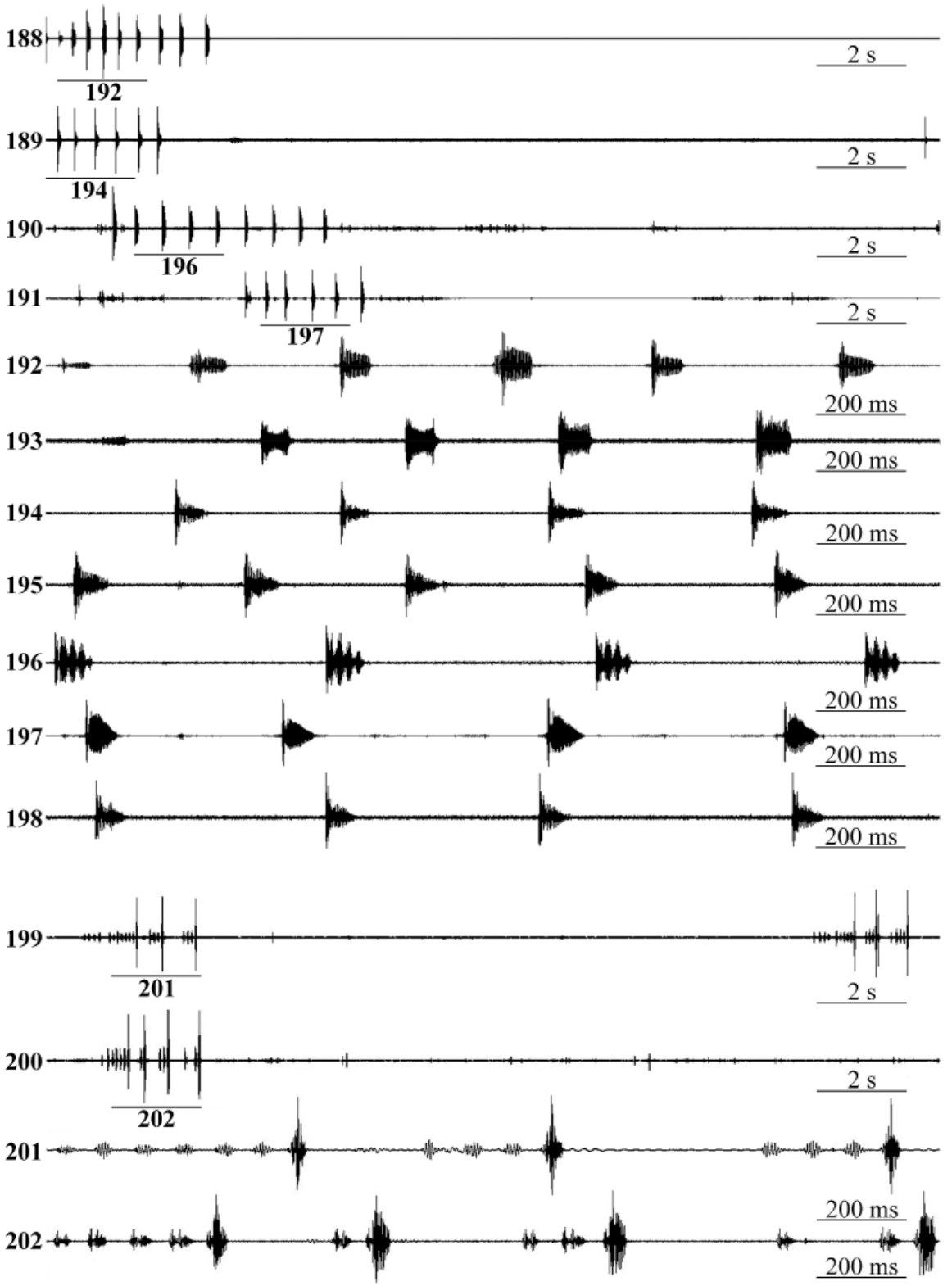
Figs 155–171. *Kybos* spp., calling signal oscillograms. 155–160 — *K. albilacustris* (155–156, 158–159 — males from Moscow Oblast, 157, 160 — male from Irkutsk Oblast); 161–168 — *K. virgator* (161, 165 — male from *Salix euxina*, 162, 166 — male from *S. purpurea nana*, 163–164, 167–168 — males from *Populus nigra pyramidalis*); 169–171 — *K. volgensis*. Faster oscillograms of the parts of signals indicated as "158–160, 165–168, and 170–171" are given under the same numbers.

Рис. 155–171. *Kybos* spp., осциллограммы призывных сигналов. 155–160 — *K. albilacustris* (155–156, 158–159 — самцы из Московской обл., 157, 160 — самец из Иркутской обл.); 161–168 — *K. virgator* (161, 165 — самец с *Salix euxina*, 162, 166 — самец с *S. purpurea nana*, 163–164, 167–168 — самцы с *Populus nigra pyramidalis*); 169–171 — *K. volgensis*. Фрагменты сигналов, помеченные цифрами "158–160, 165–168 и 170–171", представлены на осциллограммах под соответствующими номерами.



Figs 172–187. *Kybos* spp., calling signal oscillograms. 172–175 — *K. limpidus*; 176–180 — *K. butleri butleri*; 181–183 — *K. butleri matsumurai*; 184–187 — *K. rufescens*. Faster oscillograms of the parts of signals indicated as "175, 178–180, 182, and 186–187" are given under the same numbers.

Рис. 172–187. *Kybos* spp., осциллограммы призывных сигналов. 172–175 — *K. limpidus*; 176–180 — *K. butleri butleri*; 181–183 — *K. butleri matsumurai*; 184–187 — *K. rufescens*. Фрагменты сигналов, помеченные цифрами "175, 178–180, 182 и 186–187", представлены на осциллограммах под соответствующими номерами.



Figs 188–202. *Kybos* spp., calling signal oscillograms. 188–198 — *K. populi* (188, 192–193 — males from *Populus alba*, 189, 194–195 — males from *P. tremula*, 190–191, 196–198 — male from *Salix caprea*); 199–202 — *K. oshanini*. Faster oscillograms of the parts of signals indicated as "192, 194, 196–197, and 201–202" are given under the same numbers.

Рис. 188–202. *Kybos* spp., осциллограммы призывных сигналов. 188–198 — *K. populi* (188, 192–193 — самцы с *Populus alba*, 189, 194–195 — самцы с *P. tremula*, 190–191, 196–198 — самец с *Salix caprea*); 199–202 — *K. oshanini*. Фрагменты сигналов, помеченные цифрами "192, 194, 196–197 и 201–202", представлены на осциллограммах под соответствующими номерами.

inconspicuous (Fig. 125). Pygofer appendages narrow, tapering towards ends (Fig. 126), anal collar appendages narrow, falcate (Fig. 127), aedeagus without lateral processes, with wide shaft in lateral view (Figs 128–129).

HOSTS. *Populus nigra* L., related species, and their cultivars and hybrids [Zachvatkin, 1953a; Dworakowska, 1976; Ossiannilsson, 1981].

DISTRIBUTION. Europe including European Russia.

REMARK. *K. topoli* was described based on materials collected from black poplar in the environs of Luzhki Village, Serpukhov District, Moscow Oblast, in Tomilino, Lyubertsy District, Moscow Oblast and in the "Tulskie Zaseki" Nature Reserve, Tula Oblast. Our interpretation of *K. topoli* is based on investigation of specimens from the environs of Luzhki Village, collected in 1947 by one of Zachvatkin's students; these specimens fully correspond to the description of *K. abstrusus* in Dworakowska [1976] and Ossiannilsson [1981].

Kybos oshanini Zachvatkin, 1953
Figs 130–135, 199–202.

Kybos oshanini mesasiatica Zachvatkin, 1953
Kybos mesasiaticus Zachvatkin, 1953
Kybos mesasiaticus iliensis Mityaev, 1971

DESCRIPTION. Bright green with lighter spots in fore part of body. In darker specimens, forewings sometimes slightly smoky in apical parts (as on Fig. 1).

In specimens from Moscow Oblast, sternal apodemes of 2nd abdominal segment long and wide, almost parallel-sided, 3rd tergal apodemes well developed, of approximately same length and width, with diverging inner margins (Fig. 130). In specimens from Central Asia, 2nd sternal apodemes are often longer, sometimes up to three times longer than their width [Tishechkin, 2024]. Pygofer appendages narrow (Fig. 131), anal collar appendages narrow, falcate (Fig. 132), aedeagus without lateral processes, with wide shaft in lateral view (Figs 133–135).

HOSTS. *Salix* spp. from the section *Helix* in Kyrgyzstan [Tishechkin, 2024], *S. songarica* Andersson (section Amygdalinae) in Uzbekistan, *S. viminalis* (section Viminella) in Moscow Oblast [Zachvatkin, 1953a, c].

MALE CALLING SIGNALS. Signals of five males from Kyrgyzstan (the bank of the Taldy-Sai River 3 km down from Shekaftar (=Shakaptar) Village, 45 km southwest from Kerben Town, on *Salix* sect. *Helix*, 7.VII.2023, recording at 22 °C) were investigated.

Calling signal is a phrase consisting of 2–5 syllables following each other with a period of 360–760 ms; syllable repetition period usually increases towards the end of a phrase (Figs 199–202). Each syllable consists of several low-amplitude pulses following with a period of 80–140 ms, and one higher-amplitude pulse (Fig. 201). Occasionally, low-amplitude pulses are divided in two and an additional low-amplitude short pulse follows immediately before the high-amplitude one (Fig. 202).

DISTRIBUTION. Rare in central and southern parts of European Russia, widely distributed in the plains and low mountains of Central Asia along rivers and in oases but does not penetrate into the mountains above the zone of arid shrubs.

REMARKS. *K. oshanini* was described based on materials collected from *S. viminalis* in the environs of Luzhki Village, Serpukhov District; in the original description it is indicated that this species is widespread and forms several races, one of which, *K. oshanini mesasiatica*, is common in the oasis regions of Central Asia [Zachvatkin, 1953a]. Our interpretation of this species is based on investigation of specimens from the environs of Luzhki Village, collected by Zachvatkin or one of his students in 1946.

K. mesasiaticus was described based on materials from Uzbekistan in another paper published in the same collection [Zachvatkin, 1953c]. Our interpretation of *K. mesasiaticus* is based on investigation of a series of female topotypes from Uzbekistan and of materials from southern Kazakhstan and Kyrgyzstan [Tishechkin, 2002, 2024].

Comparison of specimens of *K. oshanini* from Moscow Oblast and of *K. mesasiaticus* from Central Asia showed that these names are synonyms published in the same collection of papers. Previously, as a first reviser, we chose for this species the valid name *K. oshanini* [Tishechkin, 2002]. However, in Mühlethaler *et al*. [2009] *K. oshanini* was listed under the name *K. mesasiaticus*.

Zachvatkin [1953a] pointed out that *K. oshanini* is most closely related to *K. sordidulus* Ossiannilsson, 1941, from which it differs in the details of the shape of the male genitalia, lighter coloration, and biological features. It should be added, that *K. sordidulus* is widespread in the northern regions of the Palearctic, while *K. oshanini*, on the contrary, is confined to its southern regions and is most common in the arid zone.

Kybos sordidulus (Ossiannilsson, 1941)
Figs 136–139.

Empoasca (*Kybos*) *alaskana* Ross, 1963

DESCRIPTION. Bright green with lighter and darker spots in fore part of body. Forewings smoky hyaline in apical parts, occasionally, with darkened anal and costal margins.

In shape of abdominal apodemes, pygofer appendages, and anal collar appendages similar to *K. oshanini* (Figs 136–137), but differs from it by unusually wide aedeagus shaft both in ventral and lateral view (Figs 138–139).

HOSTS. *Salix caprea*, *S. myrsinifolia*, possibly, also *S. purpurea* and *S. phylicifolia* [Zachvatkin, 1953a; Dworakowska, 1976; Ossiannilsson, 1981].

DISTRIBUTION. Apparently, Holarctic. Northern Europe [Dworakowska, 1976; Ossiannilsson, 1981], central part of European Russia [Zachvatkin, 1953a], eastern Kazakhstan [Mityaev, 2002], Siberia, northern part of the Russian Far East [Anufriev, Emelyanov, 1988], North America [Dworakowska, 1976].

REMARK. We have never seen any specimens from European Russia, but judging by the fact that this species is found in northern Europe and Siberia, it should also be found in this region. In this article photographs of specimen from Western Siberia, Krasnoyarskiy Krai are given.

Key to species of the genus *Kybos* of European Russia

1. Anal collar appendages wide at least in proximal half or two-thirds, with rounded or sharply narrowed, extended apices (Figs 11–12, 20, 39, 47, 54, 62, 68). 2
– Anal collar appendages narrow, falcate (as in Figs 75, 83, 90, 96). 8
2. Basal processes of aedeagus parallel to each other and situated close to shaft in ventral view (Figs 13–14). .... *K. lindbergi* (Lnv.).
– Basal processes of aedeagus parallel or diverging, but always located apart from shaft in ventral view (as in Figs 21–22, 40, 48, 55–56). 3
3. Sternal apodemes of 2nd abdominal segment weakly developed, almost indistinguishable (Figs 51, 65). 4
– Sternal apodemes of 2nd abdominal segment well developed, distinctly visible (Figs 17, 35, 43–44, 59). 5
4. Basal processes of aedeagus more or less parallel in ventral view (Figs 55–56). ..... *K. smaragdula* (Fall.).

– Basal processes of aedeagus diverging in ventral view (Figs 69–70). ..... *K. strobli* (Wagn.).
5. Basal processes of aedeagus almost parallel in ventral view, usually with well developed common base (Figs 21–22, 25–26, 28–29). ..... *K. betulicola* Wagn.
– Basal processes of aedeagus strongly diverging in ventral view (Figs 40, 48, 63). 6
6. 2nd tergal apodemes well developed (Fig. 45). Basal processes of aedeagus with expanded apices in lateral view (Figs 49–50). ..... *K. verbae* Zachv.
– 2nd tergal apodemes absent (Figs 36, 60). Basal processes of aedeagus with pointed apices in lateral view (Figs 41–42, 64). 7
7. Aedeagus with straight basal processes and with rather wide shaft in side view (Figs 40–42). ... *K. mucronatus* (Rib.).
– Aedeagus with basal processes somewhat bent apically and with narrow shaft in side view (Figs 63–64). .... *K. strigilifer* (Oss.).
8(1). Aedeagus with a pair of basal processes (Figs 76–79, 84–86, 91–93). 9
– Aedeagus without basal processes (as in Figs 97–99, 104–105, 111–114). 11
9. Sternal apodemes of 2nd abdominal segment short, with outer margins converging (Fig. 87). ..... *K. volgensis* Vilb.
– Sternal apodemes of 2nd abdominal segment long and wide, parallel-sided (Figs 72–73, 80–81). 10
10. Basal processes of aedeagus moderately diverging or almost parallel, usually with well developed common base and asymmetrical additional small appendages (Figs 76–79). On willows from the section Salicaster: *S. pentandra*, *S. pseudopentandra*. ..... *K. albilacustris* Tish.
– Basal processes of aedeagus strongly diverging (Figs 84–86). On willows from other sections, occasionally, also on poplar and alder. ..... *K. virgator* (Rib.)
11(8). Forewings with widely darkened anal margins (Figs 3–5). 12
– Forewings with narrowly darkened or green anal margins (as in Figs 1–2, 6). 14
12. 3rd tergal apodemes well developed, of approximately same length and width, separated by very wide notch (Fig. 101). ..... *K. butleri butleri* (Edw.).
– 3rd tergal apodemes weakly developed, very short (Figs 107, 115). 13
13. Sternal apodemes of 2nd abdominal segment about 1.5 times as long as their width at base (Fig. 106). .... *K. butleri matsumurai* (Dwor.).
– Sternal apodemes of 2nd abdominal segment about 2.5 times as long as their width at base (Fig. 115). .....*K. rufescens* Mel.
14(11). 3rd tergal apodemes weakly developed, very short (Figs. 94, 120, 125). 15
– 3rd tergal apodemes well developed, of approximately same length and width (Figs 130, 136). 17
15. Sternal apodemes of 2nd abdominal segment of about same length as their width at base, with outer margins converging (Fig. 125). ..... *K. abstrusus* (Lnv.).
– Sternal apodemes of 2nd abdominal segment more than twice as long as their width at base, more or less parallel-sided (Figs 94, 120). 16
16. Pygofer appendages of usual shape, narrow, tapering towards ends (Fig. 95). ..... *K. limpidus* (Wagn.).
– Pygofer appendages with distinct expansions in apical halves (Fig. 121). ..... *K. populi* (Edw.).
17. Aedeagus unusually wide both in ventral and side views (Figs 138–139). ..... *K. sordidulus* (Oss.).
– Aedeagus narrower, of typical shape (Figs 133–135). .... *K. oshanini* Zachv.

Discussion

As we have already indicated earlier, the species diversity of *Kybos* is greatest in the western half of the Palearctic [Tishechkin, 2024]. This is also evidenced by the present study, since of the approximately 40 Palearctic members of this genus, 17 (i. e. more than 40%) are found in European Russia.

The temporal pattern of the male calling signals in *Kybos* is quite diverse, which allows the use of acoustic characters in taxonomy. In particular, the analysis of signals confirmed that *K. albilacustris*, *K. virgator*, and *K. volgensis* are good species. Also, it was the signal analysis that showed that the taxon *matsumurai*, considered a subspecies of *K. rufescens* and more similar to it in the shape of the abdominal apodemes, is in fact a subspecies of *K. butleri.*

All *Kybos* species feed on Salicaceae (*Salix* and *Populus*) and Betulaceae (*Betula* and *Alnus*). Most species feed on several plants from the same genus. In addition, we repeatedly collected species that usually feed on plants of one genus from plants of another genus. For example, *K. smaragdula*, which usually feeds on alder, was once collected on *Salix triandra*, and *K. populi*, which usually feeds on poplars, was found on *S. caprea*. In both cases, conspecificity of males from different plants was confirmed by the calling signal analysis. Since only single individuals were collected from plants that were not typical for the species, it can be assumed that these plants were not hosts, on which an insect species completes its immature to adult life cycle but food plants in the sense of Burckhardt *et al.* [2014] i. e., plants on which adult leafhoppers feed, but do not breed and do not spend an extended period of time. On the other hand, once we found a dense population of *K. virgator*, including both adults and nymphs, on black poplar, despite the fact that this species usually feeds on willows. This indicates that poplar can be a host for this species.

Dworakowska [1976] and Mühlethaler *et al.* [2009] classified *Kybos* species into several groups but their results only partially coincide. This is probably due to the fact that different groups of taxonomic characters are not consistent with each other.

For example, in species with short and wide anal collar appendages, aedeagus always possess lateral processes; these species feed mainly on Betulaceae but occasionally, also on Salicaceae. Species with narrow falcate anal collar appendages usually feed only on Salicaceae; in most of these species the aedeagus without processes, but in *K. albilacustris*, *K. virgator*, and *K. volgensis* it has lateral processes.

The same applies to acoustic characters. For example, *K. albilacustris*, *K. virgator*, and *K. volgensis* are closely related in morphological characters, but strongly differ in the calling signal temporal patterns. *K. butleri* and *K. rufescens* are similar in morphological characters and coloration, but also strongly differ in the signal patterns. On the other hand, in *K. lindbergi* and *K. volgensis* or in *K. rufescens* and *K. limpidus* signals are quite similar, but species in both pairs belong to different morphological groups.

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