

Polymorphism of the meadow spittlebug *Philaenus spumarius* (Linnaeus, 1758) (Auchenorrhyncha: Aphrophoridae) in Central part of European Russia

Полиморфизм пенницы *Philaenus spumarius* (Linnaeus, 1758) (Auchenorrhyncha: Aphrophoridae) в центре европейской части России

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Ключевые слова: Philaenini, *Philaenus spumarius*, полиморфизм, Нижегородская, Владимирская области, Татарстан, Марий Эл.

Abstract. This study summarizes scattered data on polymorphism of the meadow spittlebug *Philaenus spumarius* (L.) (Auchenorrhyncha: Aphrophoridae) in the central part of European Russia where 16 pure morphs and one mixed morph have been identified. Abundance and diversity of morphs of this species in different areas of the central part of European Russia have been assessed.

Резюме. Проведено исследование, обобщающее разрозненные данные по полиморфизму пенницы *Philaenus spumarius* (L.) (Auchenorrhyncha: Aphrophoridae) в центре Европейской части России. Выявлено 16 чистых морф пенницы и одна смешанная. Приводится оценка богатства и разнообразия морф пенницы в разных областях центра Европейской части России.

Introduction

Polymorphism is a wide-spread natural phenomenon caused by genetic variability and adaptations. As a rule, it provides phenotypic diversity of population in various natural conditions. Polymorphism is the source of evolutionary transformations of the intra-population genetic diversity into the variations which differ populations spatially and ecologically. Thus, polymorphism forms the basis for species formation. Although nowadays populations are studied by different characteristics and by different methods, polymorphous species remain the most convenient objects for such studies. Studies of polymorphous species of different systematic groups demonstrated that populations are marked by rather constant gene frequency ratios and are stable over time.

This study is devoted to polymorphism of the meadow spittlebug *Philaenus spumarius* (Linnaeus, 1758) (Auchenorrhyncha: Aphrophoridae) in the Central part of European Russia. This species is the popular object of studies due to its natural occurrence and high diversity of morphs. From the practical point of view, this species

is interesting due to its significant role in transfer of the pathogenic agents of plant diseases.

The studies of phenotypic manifestations of polymorphism of the spittlebug have been performed in Western Europe and in Russia at the end of 20th and at the beginning of 21st centuries. The composition of morphs is described for Italy, Poland, Scandinavia, Turkey, Great Britain, Czech Republic, Portugal [Raatikainen, 1971; Ossiannilsson, 1978; Kosonocka, 1981; Quartau, Borges, 1997; Klimaszevski, Yurtsever, 2000; Borges et al., 2018]. In Russia polymorphism of the meadow spittlebug has been studied in the Urals [Beregovoj, Aronov, 1969], Far East [Kolova, 2010], Arkhangelskaya Oblast [Majorova, Kolova, 2015], Altai Mountains [Majorova, Kolova, 2019]. On the territory of European Russia, which belongs to Eastern Europe, the polymorphism of the meadow spittlebug has been deeply studied only in Nizhegorodskaya Oblast [Kolova, Beketova, 2007; Guseva, Kolova, 2021]. It should be noted that the studies of the meadow spittlebug polymorphism in Russia are limited to phenotype studies. In European countries studies of the spittlebug genotype based on its DNA sequencing have been completed in the recent years. European researchers develop an interest in this field due to the fact that *P. spumarius* is the main transmitter of the plant pathogenic bacteria *Xylella fastidiosa*, which causes serious diseases in different plants around the world [Evangelou et al., 2021]. In Europe *X. fastidiosa* was described for the first time in South Italy as the bacteria, which causes olive quick decline syndrome. Considering that *X. fastidiosa* is a serious potential hazard for olive growing in Greece, a study was arranged which was dedicated to the genetic variation in populations of three spittlebug species in Greece: *P. spumarius*, *P. signatus* and *Neophilaenus campestris* [Evangelou et al., 2021]. The structure of nuclear and mitochondrial DNA has been analysed. The similar

studies have been performed in Poland [Kuznetsova et al., 2003; Maryńska-Nadachowska et al., 2012], France [Cunty et al., 2020], Great Britain [Brakefield, 1990], Canada [Steward, Beckenbach, 2005]. However, such studies have not been performed in Russia.

Different researchers enlist different number of the meadow spittlebug morphs depending on identification of transitional morphs. Thus, according to the data of Beregovoj [1966, 1967, 1971] and Raatikainen [1971] 20 pure morphs and four mixed morphs are registered for the meadow spittlebug. All morphs, mentioned below, are represented on Fig. 1.

Materials and methods

This research is mainly based on Auchenorrhyncha collection of Prof. Dr. Anufriev, gathered in summer season from 2000 through 2010 in different regions of the central part of European Russia as well as on the materials collected by the author. Thus, in August 2000 the insects were collected in Nizhegorodskaya Oblast, in 2002 in Vladimirskaya Oblast, in 2005 in Kaluzhskaya Oblast, in 2005 and 2007 — in Republic of Mordovia, in 2006 — in Penzenskaya Oblast, in 2007 — in Vologodskaya Oblast, in 2006 and 2010 — in Republic of Tatarstan, in 2007 and 2010 — in Republic of Mari El.

For analysis these materials have been combined with collections gathered by other researchers in Nizhegorodskaya and Vladimirskaya Oblasts in 2007 and 2021 [Kolova, Beketova, 2007; Guseva, Kolova, 2022].

The present work is registered in ZooBank (www.zoobank.org) under LSID urn:lsid:zoobank.org:pub:5DB8222A-4B7B-42CE-A999-78516A014118

Results

Table 1 demonstrates that in European Russia 16 pure morphs and one mixed morph have been registered.

Table 1. Diversity of morphs of the meadow spittlebug in Central part of European Russia (%)
Таблица 1. Разнообразие морф пенницы в центре европейской части России (%)

Morphs	Regions							
	Mordovia	Mari El	Tatarstan	Penza	Nizhny Novgorod	Vladimir	Kaluga	Vologda
<i>typ</i>				48.7	70.3	48.1	72.0	58.8
<i>pop</i>	0	1.9	5.8	14.5	7.0	11.6	0	5.8
<i>qua</i>	0	0	0.6	7.2	0.8	3.2	4	0
<i>alb</i>	3.8	0	0	7.2	2.7	6.9	0	5.8
<i>lop</i>	11.5	3.8	0	0	1.0	2.1	4	0
<i>mar</i>	0	7.5	0	0	1.6	2.5	0	0
<i>lat</i>	0	5.7	0	0	0.9	1.4	0	0
<i>gib</i>	0	0	0	0	2.2	2	4	0
<i>ust</i>	3.8	0	0	0	0.1	0	0	0
<i>fla</i>	0	1.9	3.2	7.2	2.8	13.8	8	17.6
<i>pra</i>	0	1.9	2.6	0	1.8	0.9	0	0
<i>tri</i>	15.4	7.5	5.8	0	5.7	1.2	8	11.8
<i>lce</i>	0	1.9	0.6	14.1	1.6	1.5	0	0
<i>hex</i>	0	0	0	0	0.1	0	0	0
<i>vit</i>	0	0	1.3	0	0.9	1.3	0	0
<i>bin</i>	0	0	0	0	0.2	0	0	0
<i>fla-mar</i>	0	1.9	0	0	0.2	1.5	0	0
Number of insects	26	53	162	14	1722	278	25	17
Number of morphs	5	10	8	6	17	14	6	5

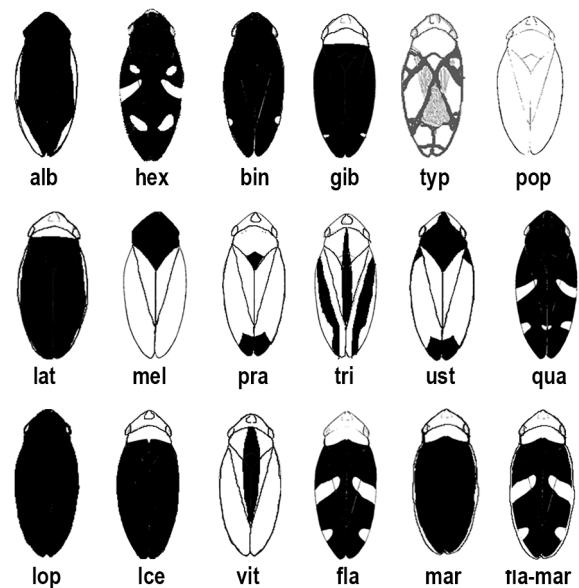


Fig. 1. Colour patterns of *Philaenus spumarius* (L.).

Рис. 1. Варианты окраски *Philaenus spumarius* (L.).

The maximum number of morphs has been recorded from Nizhegorodskaya Oblast, which probably, due to the largest number of studies in this territory, and consequently the largest number of collected insects and maximal coverage of different natural areas.

Vladimirskaya Oblast takes the second rank for the number of registered morphs. 13 out of 14 total pure morphs and one mixed morph have been registered there. For Vladimirskaya Oblast the data describing collection of Dr. Anufriev gathered in the Meshchyora National Park in 2002 have been combined with the data describing collection gathered in Nikolgor settlement [Guseva, Kolova, 2021].

Mari El Republic takes the third rank for the number of registered morphs. 9 pure morphs and one mixed

morph have been registered. The insects have been collected in Bolshaya Kokshaga Natural Reserve.

In the Republic of Tatarstan the insects were collected in Volzhsko-Kamski Natural Reserve, where eight morphs have been registered (Fig. 1).

In other regions, the insects were collected in the Natural Parks: Nizhnyaya Kama (Mordovia) and Ugra (Kaluzhskaya Oblast); in the Natural Reserves: Privolzhskaya Lesostep (Penzenskaya Oblast) and Darvinski (Vologodskaya Oblast). The material is not abundant from these regions, the number of morphs does not exceed six.

The qualitative analysis of morphs demonstrated that the morph *typica* (*typ*) characterized by interchanging melanic and pale elements is the most common one, which was found in all studied locations. It is the most widespread and abundant morph in all studied regions. Its share among other morphs almost in all locations (except for Penzenskaya and Vladimirskaya Oblasts) exceeds 50 %. Meanwhile, in these two Regions the decreased abundance of *typ* correlates with the increase in abundance of the pale morph *populi* (*pop*), and two melanic morphs: *flavicollis* (*fla*) in Vladimirskaya Oblast, and *leucocephala* (*lce*) in Penzenskaya Oblast, respectively.

Among pale morphs in the Central part of European Russia, four other pure morphs (in addition to *pop*) have been registered: *trilineata* (*tri*), *vittata* (*vit*), *praeustata* (*pra*), and *ustulata* (*ust*) five morphs in total. The total number of melanic morphs is 11. Beside the mentioned above morphs, eight other pure morphs have been registered: *gibba* (*gib*), *lateralis* (*lat*), *marginella* (*mar*), *quadrinaculata* (*qua*), *leucophthalma* (*lop*), *albomaculata* (*alb*), *hexamaculata* (*hex*), *binotata* (*bin*) and one mixed morph *flavicollis-marginella* (*fla-mar*).

It was observed that the melanic/pale morph ratio in populations of the meadow spittlebug is connected with the type of habitat: in dry, well-lit, warm habitats, pale morphs prevail, while in the humid and shadowy habitats, on the contrary, melanic morphs prevail [Kolova, Beketova, 2007]. The Meshchya National Park is characterized by fringe position of botanic and geographic zones, where the Northern taiga zone meets the Eastern broad-leaved forest zone [Mil'kov, Gvozdeczkij, 1976; Rakovskaya, Davydova, 2001]. Thus, this area includes different habitats formed by both taiga species and plants of mixed coniferous-broad leaved and broad-leaved forests. Moreover, here there are swamps of different types as well as elements of steppe flora. Probably, such contrast in natural conditions on relatively small area causes maximal, largest shares of melanic and pale morphs of meadow spittlebug in comparison to other regions.

In the Privolzhskaya Step Natural Reserve the areas of Northern steppes interchange with the forest formations [Mil'kov, Gvozdeczkij, 1976; Rakovskaya, Davydova, 2001]. It can be the root-cause of rather high ratio of the pale morph *pop* (14.3 %). In Tatarstan the number of registered pale morphs (4) out of eight total registered pure morphs, exceeds over the number of melanic morphs (3). The Nizhnyaya Kama National

Park is located on the border of broad-leaved forests and meadow steppes. The peculiarities of this area are "light-demanding" tree species forming the forests, insular spatial pattern of forests, consisting of pine, birch, and aspen. Such forests form well-lit, dry, warm habitats, providing favourable conditions for prevalence of pale morphs of the meadow spittlebug.

The morph *fla* was registered in all locations, except for Mordovia, while its maximal ratio was recorded on the North, in Vologodskaya Oblast. It supports the pattern revealed earlier [Kolova, Beketova, 2007], which describes prevalence of melanic morphs in Northern regions.

The morphs with the lowest occurrence and distribution, found only in Nizhegorodskaya Oblast as single insects, are *hex* (0.1 %) and *bin* (0.2 %). The morphs *ust*, *mar*, *lat* and *gib*, as well as the mixed morph are also rather rare.

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