Varietal preferences of *Rhopalosiphum padi* Linnaeus, 1758 in the Far East South

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**Abstract.** The article discusses the varietal preference of *Rhopalosiphum padi* Linnaeus, 1758 in the Far East South, and describes the phenology of the pest. It was found that the most optimal for the aphids development and nutrition were Primorskaya 40, Khabarovchanka, Primorskaya 39 wheat varieties, as well as barley varieties Primorskiy 89 and Vostochny. The least suitable were the Primorskiy 98 and Primorets barley varieties. Wheat and barley species-specific effects on the *Rhopalosiphum padi* Linnaeus, 1758 development and productivity in the Russian Far East South is poorly understood and requires further research.

1. Introduction

Among agricultural plants, cereals are of paramount importance. As their dangerous pests, cereal aphids have been known for quite a long time. The high ecological plasticity of aphids allows them to form resistance to the applied pesticides and varieties with secondary metabolites increased content and their oxidation products quickly. This makes it necessary to search for alternative resistance mechanisms, the diversity of which will provide a basis for creating varieties that do not cause intraspecific genotypic variability of pests. The host plant as a biocenotic factor is of crucial importance in the population-biological characteristics of phytophages, including aphids formation [1-6].

Phytophages trophic adaptations were primarily carried out by optimizing the substances use, that ensure their plastic and energy metabolism in the ontogenetic conditions, diurnal, and other changes in the metabolism of both producers and consumers [7-14].

Currently, 5581 aphids species are known, of which 100 cause significant damage to agricultural crops) [1]. Several species damage grain crops in the Far East, but the greatest damage is caused by the English grain (Sitobion avenae Fabricius, 1775), wheat (Schizaphis graminum Rondani, 1852.), and Bird cherry-oat aphids (Rhopalosiphum padi Linnaeus, 1758). Nutritional adaptation, harmfulness of these insects was formed in the process of long-term adaptations to the plant juices diet. Among aphids, 5% of the species are polyphages, and 95% are oligophages and monophages [1]. Parthenogenesis emergence led to the appearance of heterogony, which, along with live birth, allowed aphids to increase their numbers extremely quickly, and development cycles by superimposing generations reduced the pre-productive period to several days [13]. In mild winters, where the primary host is absent or small, as well as in greenhouses, aphids may not complete their life cycle and overwinter angolocyclically. In this way, aphids appear earlier in crops, their number increases faster,
and the degree of damage increases [4]. This aphid feature is important for agricultural practice, as it requires regular monitoring of the population and changes in nutritive and habitat conditions [5]. In addition to obvious harm, aphids are vectors of 275 phytoviruses [2]. Viruses carried by aphids cause greater economic losses than nutrition itself. Fungal infections, that develop on the aphids carbohydrate-rich excreta, reduce plant photosynthesis [8, 2], which makes it promising to study the formation of trophic relationships between aphids and forage plants in relation to differences in their life cycles and reproductive strategies within the framework of the biocenotic theory. In connection with the search for new ways to contain their harmfulness [11], the analysis of varietal preferences of cereal aphids is of particular relevance, which determined the tasks of our research.

2. Materials and methods
The research object was the Bird cherry-oat aphid (*Rhopalosiphum padi* Linnaeus, 1758), which belongs to the heterocyclic holocyclic species. As the model primary food plant for *Rh. padi*, the crab cherry *Prunus padus* L., 1753 was selected. The aphid development passed on samples with the same colonization by the pest background. Records were carried out on 100-200 randomly selected annual shoots. The number of aphids, sexuparas, oviparous, and males were counted. Shoots were selected from different plants tiers in order to maximize the coverage of the entire crown; they were also marked with tags. The insects lived without insulators. The records were taken at 10-day intervals. The aphids density was calculated on 10 discount buds and 100 leaves.

The studied samples were evaluated for 2 years. The crop laying was carried out according to the N.I.Vavilov Research Institute of Plant Industry methods adopted for the studied crop. Tillage and crop care were carried out in accordance with the agrotechnical rules adopted for this zone. The work was carried out on a natural background of pest colonization, without insulators. The assessment was carried out by visual inspection on three indicators: the percentage of colonized plants, the absolute number of aphids on all plants in the tillering phase, and the damage score in the flowering phase [14].

To assess the colonization was used an adopted by the N.I.Vavilov Research Institute of Plant Industry international scoring system, in which: 1- individuals on one of the lower leaves; 3 - small colonies of 3 to 5 individuals on two to three lower leaves; 5 – medium-sized colonies of 10 to 15 individuals on half of all leaves; 7 – medium-sized colonies of more than 20 individuals on 2/3 of all leaves; 9 - large and medium-sized colonies on the entire plant, high colonization. Simultaneously with the field assessment, a laboratory study of the cereal varieties for nutrition and development of aphids in an insectarium (25 °C, 16 hours, 85% humidity) favorability was conducted. The following indicators corresponded to the favorable aphids development: low mortality of migrants, a greater number of descendants 9 days after the plant was colonized, a shorter period from birth to the reproduction beginning, and a higher number of descendants a month after the plant was colonized. Based on the experiment results, statistical processing was performed using the method of the dispersion analysis using Past 4.03.

3. Results and discussion
Observations on the *Rh.padi* autumn generations appearance timing showed that the earliest appearance of sexuparas was observed on 23-31. 07 in 2019 and 2020. Males began to appear in August (5.08-25.08) when the first oviparous matured. Oviparous started eggs laying, starting from the second half of September, until the end of leaf fall, the places of laying were noted at the buds or in the bark folds at the shoots joints. The latest leaf fall was observed in November 2019, which caused a high number of colonized buds and the number of eggs in the spring of 2020. So, in 2019, the number of eggs per 100 registered buds was 250±4.150, in 2020-320±4.150, while the number of buds colonized with eggs was 150±2.125 and 140±2.125 for 2019 and 2020, respectively. The number of eggs significantly (ɕ=0.5) depended on the location and shape of the buds on the shoots. In healthy buds adjacent to the shoot, aphids were more likely to lay eggs, avoiding those affected by rot.

The subsequent egg development depends on the development conjugation of the founder larvae and fundatrigenic generations with the host plant [9]. In our studies, the release of founder larvae from
eggs occurred with the appearance of green cones and the beginning of budding, the beginning of reproduction coincided with the phase of "white buds" and the beginning of flowering. Aphids number increased rapidly before the flowering beginning and was associated with the appearance of the first migrants. This is confirmed by the research of Gandrabur [10].

It is known that the colonization of Rh.padi migrants is associated with the agrobiocenoses colonization and the viral infection transfer [7]. The appearance of winged aphids depends on their numbers, temperature, wind speed, precipitation, and other abiotic environmental conditions necessary for taking off and flight [5].

According to our observations, the first Rh.padi colonies were recorded in winter grain fields in the third decade of April – the first decade of May. On spring crops, aphids are recorded in the second-third decade of June. Since the third decade of June, viral manifestations were observed in grain plantings: leaf roll, leaf curl, inter-vein chlorosis, and dwarfism. The greatest pests number (118.5±1.115 individuals/plant) and maximum virus incidence score (3.82±1.402 points) were observed in 2020 on the spring barley varieties of the competitive variety trials: Primorsky 98, Primorsky 216, Primorsky 217, Primorsky 218, Primorsky 222, Primorsky 228, Primorsky 229, Primorsky 224; in the spring soft wheat collection nursery: Siberian Alliance, Gornouralskaia, and in the environmental testing on varieties of spring durum wheat: Solnechnaya 573, Voronezhskaya 9. Moreover, on spring soft wheat of the Gornouralskaya variety, there were also signs of phytoplasma infection, such as the mop-top virus.

In General, weather conditions during the study period did not contribute to the aphids development, their numbers on wheat and barley were not high and differed slightly over the years (figure 1). The entire damage to all plantings was 26.6 and 26.7% for 2019 and 2020, and the percentage of populated plants was 21 and 24%, respectively.

Figure 1. Grain crops damage and colonization with aphids.

In a laboratory experiment, it was found that on spring soft wheat varieties of competitive variety testing Primorskaya 40 and Primorskaya 248, barley varieties Primorets, Primorskiy 89 and Vostochny, single migrants, in most clones, do not have winged individuals among the first descendants, even with a fairly high density of their colonies (table 1).
Table 1. The number of winged individuals and nymphs in the Bird cherry-oat aphids various clones migrants offspring when feeding on wheat and barley.

| Crop | Variety | Clone, Ne | Quantity of individuals in the colonies | The composition of the colonies, % |
|------|---------|-----------|-----------------------------------------|----------------------------------|
|      |         |           |                                        | Winged individuals | Nymphs |
|      |         |           | 213±42.2 | 3.3±0.3 | 18.8±3.4 |
|      |         | 2         | 599±49.3 | 2.0±0.1 | 3.3±0.7 |
|      | 219     | 2         | 393±50.1 | 0.9±0.1 | 3.1±0.9 |
|      | 219     | 4         | 393±50.1 | 0.8±0.1 | 3.3±0.7 |
|      | 219     | 5         | 294±32.3 | 4.7±1.2 | 2.5±0.6 |
|      | 219     | 1         | 359±68.4 | 3.2±0.9 | 4.5±1.3 |
|      | 222     | 2         | 1098±96.2 | 4.8±0.9 | 17.8±3.1 |
|      | 222     | 3         | 322.5±82.3 | 4.5±0.9 | 8.9±2.05 |
|      | 222     | 4         | 415±36.3 | 0.8±0.1 | 3.2±0.62 |
|      | 222     | 5         | 413±36.3 | 4.6±0.9 | 3.2±0.62 |
|      | 222     | 1         | 851±59.2 | 5.5±0.9 | 6.6±0.9 |
|      | 219     | 2         | 2179±97.1 | 6.2±1.1 | 14.3±1.6 |
|      | 219     | 3         | 628±48.2 | 14.8±2.1 | 15.3±1.9 |
|      | 219     | 4         | 1965±110.2 | 20.4±3.2 | 17.7±2.8 |
|      | 219     | 5         | 538±42.2 | 4.6±0.8 | 27.5±3.3 |
|      | 219     | 1         | 2411±184.2 | 9.25±1.2 | 18.9±2.2 |
|      | 39      | 2         | 425±43.3 | 3.5±0.5 | 23.2±3.4 |
|      | 39      | 3         | 2500±105.2 | 5.2±0.8 | 14.5±1.6 |
|      | 39      | 4         | 478±52.3 | 1.2±0.1 | 2.9±0.3 |
|      | 39      | 5         | 425±43.3 | 1.2±0.1 | 14.5±0.3 |
|      | 239     | 1         | 346±41.0 | 0 | 0 |
|      | 239     | 2         | 478±52.2 | 0 | 0 |
|      | 239     | 3         | 514±91.2 | 0 | 0 |
|      | 239     | 4         | 358±38.3 | 0 | 0 |
|      | 239     | 5         | 308±51.2 | 0 | 0 |
|      | 40      | 1         | 694±72.2 | 0 | 7.4±1.0 |
|      | 40      | 2         | 1200±201.25 | 0 | 6.4±0.5 |
|      | 40      | 3         | 793.2±92.3 | 0 | 24.2±3.7 |
|      | 40      | 4         | 308±51.2 | 0 | 4.9±0.7 |
|      | 40      | 5         | 243±42.2 | 0 | 11.5±2.1 |
| Barley | 98     | 1         | 346.25±41.2 | 0 | 0 |
| Barley | 98     | 2         | 665.2±82.5 | 0 | 6.5±0.9 |
|      | 98      | 3         | 1.2±0.1 | 2.96±0.3 | 1.2±0.1 |
|      | 98      | 4         | 358.2±38.2 | 0 | 20.1±3.7 |
|      | 98      | 5         | 791±93.3 | 7.2±0.3 | 30.5±4.9 |
|      | 98      | 1         | 213.25±42.3 | 0.9±0.1 | 2.5±0.6 |
|      | 98      | 2         | 308.25±52.2 | 0 | 0 |
|      | 89      | 3         | 213.25±42.3 | 0 | 0 |
|      | 89      | 4         | 225.25±42.3 | 0 | 0 |
|      | 89      | 5         | 213.25±42.3 | 0 | 0 |
|      | 89      | 1         | 346.25±41.2 | 0 | 0 |
|      | 89      | 2         | 665.25±82.3 | 0 | 0 |
|      | 89      | 3         | 478.2±52.2 | 0 | 0 |
|      | 89      | 4         | 665.25±83.2 | 0 | 0 |
|      | 89      | 5         | 470.25±85.2 | 0 | 0 |
At the same time, the composition of the single wingless females offspring differed in the winged individuals appearance in all clones. The correlation coefficient between the number of nymphs in the offspring of emigrants and wingless females was $+0.75\pm0.21$ ($t_r=3.2$). This characterizes the existence of endogenous birth rhythms of certain morphs offspring that are characteristic of wingless and winged females, as well as gradations in the degree of sensitivity of individuals in clones to the "group effect", which is considered one of the main factors determining the presence of wings in summer aphids generations [3].

The quality of food is one of the most important factors that determine insect life. In our experiment, the mortality rate of migrants fed on different varieties of wheat and barley was quite high (figure 2).

![Figure 2. Mortality of migrants when feeding on wheat and barley varieties, 2020.](image)

Thus, the maximum migrants mortality was observed in the Primorskaya 219 wheat variety (5.2%) and the Primorskiy 98 and Primorets varieties (15 and 25%, respectively). It is known that the aphids food preferences determine the substances of cereals that provide plants with an anti-sentic barrier, such as gamma-aminobutyric acid, azetidine-2-carboxylic acid, latirin, cyanalanine, moskalin, etc. [12]. In the conditions of the Far East South, the content of alkaloids, terpenoids and tannins in barley and wheat varieties was not studied.

However, the assumption about the influence of immune barriers and the substances, that determine them, on the aphids development and reproduction is confirmed by other indicators (figure 3).

In the Primorskaya 219 wheat variety and the Primorskiy 98 and Primorets barley varieties with high mortality, there were also violations of the population dynamics rhythms. Migrants were less likely than other varieties to choose them for settlement, the number of offspring 9 days after the migration was significantly lower ($\pm1.123$ individuals), and a month after settlement there was no increase in offspring. On average, the number of descendants of migrants in these varieties decreased by 68.3%.
Thus, the most suitable for the aphids development and nutrition were wheat varieties Primorskaya 40, Khabarovichanka, Primorskaya 39 and Primorskaya 239, barley: Primorsky 89 and Vostochny. They showed the maximum fecundity of migrants. The least suitable varieties were barley Primorskiy 98 and Primorets, as well as wheat Primorskaya 219, where there was a high mortality rate of migrants. Mechanisms of aphids varietal preferences due to the cereal plants immune barriers require further study.

Figure 3. Dynamics of the migrants descendants number, 2020.

4. Conclusion
Grass aphids are widespread pests of cereals and grasses. Sporadic increases in their numbers cause the need for protective measures in the Russian Far East South. The harmfulness of aphids is associated with a complex of trophic relationships throughout the life cycle, their load on plants at various stages of organogenesis. Ontogenetic and related organogenetic specificity in phloem-feeding aphid species is strictly determined by the need for nutrition in areas of assimilants pronounced flow. The wheat and barley specific impact on the aphids development and productivity is poorly understood in the Russian Far East South and requires further research.

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