Habitat and Specificity of the Satyridae (Lepidoptera, Satyridae) of Kurgan Oblast

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Abstract. In the South Trans-Urals, the Satyridae family is represented by 24 species, including P. afra and E. medusa, the species listed among the endangered species of Kurgan Oblast. Among the Satyridae inhabiting the region, C. tullia is the only species found in the Holarctic habitat; the rest belong to the Palearctic butterflies. In the region, the majority of the species spend the winter as a larva; two species live through the winter as a pupa. For three species, C. hero, P. afra, and C. persephone, the winter stage has not been found. By the trophic specialization of the larvae, the Satyridae are represented by broadly oligophagous and broadly polyphagous larvae. Based on the emergence timing, the imagoes of the Satyridae living in the South Trans Urals can be divided into three phenological groups: early summer (6 species), summer (15 species) and late summer (1 species). Generally, the Satyridae fauna of the region can be referred to as inhabitant in the forest-steppe area. By the landscape and biotopic allocation, the Satyridae of the region can be conventionally divided into four ecological groups: the inhabitants of the pine and small-leaved forests, the inhabitants of the forest-outlier and meadow landscape, inhabitants of the steppe-heaths and eurybionts. The greatest diversity of the species was found in the open space fauna (clearcuts and forest openings) of the pine and small-leaved forests. The similarity of the species composition of the Satyridae inhabitant in the forest-outlier and steppe landscapes constitutes 53%. This is explained, first of all, by the abundance of the Poaceae being the fodder plans of the caterpillars for the majority of the species.

1. Introduction
The studies of the Papilionoformes inhabiting Kurgan Oblast, including Satyridae, were initiated by Yu.M. Kolosov [1] and V.A. Shchuko [2]. Much later, in the middle of the past century, the studies of the butterflies inhabiting the region were continued by N.M. Voskresensky [3-5]. The collection of the Lepidoptera carried out by N.M. Voskresensky in the territory of the region for seven years enabled him to publish a list of 72 species of diurnal butterflies, which also included ten species of the Satyridae family. Further studies of the Satyridae of the Trans-Urals and Western Siberia were carried out by Yu.P. Korshunov [6-8], V.P. Starikov and N.A. Utkin [9, 10]. The most comprehensive and detailed data of the Lepidoptera found in Kurgan Oblast including Satyridae are provided in the works by N.A. Utkin [11, 12]. According to the available literature, in the territory of Kurgan Oblast the Satyridae family is represented by 24 species. The South Trans Urals groups of this group still remain understudied.
2. Research materials and methods

Kurgan Oblast lies on the borderline between the Urals and Siberia, in the south of the West Siberian Plain between 56°60'N and 54°10'N, 62°00'E and 68°45'E. The major part of the Oblast territory belongs to the forest-steppe zone. The climate of the region is continental, with a severe winter with frequent blizzards and a short, but hot summer with regular droughts [13].

The average duration of the summer period is 170-175 days. In January, the coldest month of the year, the average temperature is -17…-19°C. The absolute minimum reaches -47…-50°C. The snow cover lies, on the average, for 145-150 days. Short with frequent recurrences of cold weather, spring in Kurgan Oblast lasts for one month only.

The average duration of the summer period is 130-135 days. In July, the warmest month of the year, the average temperature is +17…+19°C. The absolute maximum equals to +39…+41°C. The frost-free period with the average daily temperatures above +15°C lasts for about 80 days. In August, the temperature drops, especially in the night time. In the second half of August, ground frosts are possible.

The autumn period lasts for around one month. In this period, the average daily temperature falls from +11.5°C to -1.5°C, cloudy days become more frequent, it begins raining.

The studies were carried out in the years 2000-2002 and 2014-2018. The imagoes of the butterflies were captured with a standard entomological butterfly net. The egg-laying was monitored in the places of the butterflies' habitat; in the egg-laying spots, a silk bolting cloth or gauze nursery was placed to observe the larvae and pupae in the natural environment.

Some eggs were picked and placed into glass or plastic containers to observe all the stages in the laboratory conditions. Moreover, some larvae and pupae collected in nature were risen in the laboratory environment.

Besides the material collected by the authors, the collections of the Zoology and Bioecology Department of Kurgan State University were studied.

Species identification was based on the tables developed by Yu.P. Korshunov [14]. The species diversity of the Satyridae was evaluated with the five-score upper-bounded logarithmic scale of Yu.A. Pesenko; the similarity of species composition of different habitats was evaluated with the similarity measure of Paul Jaccard [15]. The studied species habitats were characterized based on the typology developed by K.B. Gorodkov [16].

3. Results and discussion

As a result of the previous study, the inhabitance of 24 species of the Lepidoptera of the Satyridae family in the territory of the region was confirmed [17]. Two of them, Proterebia afra (Fabricius, 1787) and Erebia medusa (Denis et Schiffermuller, 1775) are listed among the Endangered Species of Kurgan Oblast [18] as species with reducing population within the given habitat (category II). In the Oblast territory, only several individuals of these species have been captured [12, 19]. By diversity of the species, the other representatives of the Satyridae in the region can be divided into four groups. There are eight species rare for the region: Lopinga achine (Scopoli, 1763), Coenonympha arcania (Linnaeus, 1761), Coenonympha leander (Esper, 1784), Hyponephele lupina (Costa, 1836), Erebia ligea (Linnaeus, 1758), Arethusana arethusa (Denis et Schiffermuller, 1775), Hipparchia autonoe (Esper, 1784), Chazara briseis (Linnaeus, 1764). The small-numbered group encompasses five species: Coenonympha tullia (Muller, 1764), Coenonympha hero (Linnaeus, 1761), Erebia aethiops (Esper, 1777), Chazara persephone (Hübner, 1805), Oeneis tarpeja (Pallas, 1771). There are only two species of the Satyridae common for the region: Lasiomnata petropolitana (Fabricius, 1787) and Melanargia russiae (Esper, 1784). The most numerous species are the following seven: Lasiomnata maera (Linnaeus, 1758), Coenonympha glycerion (Borkhausen, 1788), Coenonympha pamphilus (Linnaeus, 1758), Maniola jurtina (Linnaeus, 1758), Hyponephele lycaon (Rottemburg, 1775), Aphantopus hyperantus (Linnaeus, 1758), Minois dryas (Scopoli, 1763). None of the most numerous species of the Satyridae has been found in the territory of Kurgan Oblast.

Among the 24 species resident in the region, only one is found in the Holarctic habitat; the rest belong to the Palearctic butterflies. C. tullia lives in the Holarctic circum-temperate habitat. By the specificity
of their habitats, the Palearctic species can be divided into nine groups. The Trans-Eurasian temperate-subtropical type of habitats encompasses those of six Satyridae species: L. achine, C. glycerion, C. hero, E. ligea, A. hyperantus, M. dryas. L. petropolitana belongs to a Trans-Eurasian temperate type of habitat. The habitats of the three species, L. maera, C. pamphilus and M. jurtina belong to the Central-Palearctic temperate-subtropical type. The Euro-Siberian Central Asian temperate-subtropical type of habitat is typical only for O. tarpeja. There is only one species, E. medusa, which habitat belongs to the Euro-Siberian Middle Asian type. For eight species: C. leander, H. lycaon, H. lupina, P. afra, A. arethusa, C. briseis, C. persephone, M. russiae, the typical habitat is Euro-Kazakhstan temperate-subtropical type. The habitat of one species, E. aethiops, belongs to the Euro-Baikal temperate-subtropical type. The Euro-Baikal suboreal type of habitat is only typical for H. autonoe. Only C. arcania is found in the West-Palearctic type of habitat.

Based on the winter-spending stages, the Satyridae of Kurgan Oblast can be divided into two ecological groups: those spending winter as a larva and those spending winter as a pupa.

The first group consists of 19 species: L. achine, L. maera, C. tullia, C. glycerion, C. arcania, C. leander, C. pamphilus, M. jurtina, H. lycaon, H. lupina, A. hyperantus, E. ligea, E. aethiops, E. medusa, A. arethusa, H. autonoe, M. dryas, C. briseis, M. russiae.

The second group is represented by only two species, L. petropolitana and O. tarpeja.

For three species, C. hero, P. afra, and C. persephone, the winter stage has not been found.

By the trophic specialization of the larvae, the Satyridae are represented by broadly oligophagous and broadly polyphagous larvae. The oligophagous group includes 19 species; the larvae of these species can only develop on the plants of the Poaceae family. All of them are broadly oligophagous, i.e. they feed on the plants belonging to different genera of the same family. There are five polyphagous species: C. tullia, C. hero, E. ligea, A. hyperantus and H. autonoe. The larvae of these species feed on the plants of the Poaceae and Cyperaceae families. As these plant families belong to different orders, the larvae feeding on them are recognized as broadly polyphagous.

Based on the imago emergence time, the South Trans Ural representatives of the Satyridae family can be divided into three phenological groups. Starting from the second decade of May, the first representatives of the early summer phenological group, L. achine and L. maera begin to emerge. In the third decade of May, the imagoes of L. petropolitana, C. leander, C. pamphilus and O. tarpeja appear.

In June, the summer phenological group consisting of C. tullia, C. glycerion, C. hero, C. arcania, M. jurtina, H. lycaon, H. lupina, E. aethiops, A. arethusa, M. dryas and M. russiae begins to emerge. This is the season of the peak species diversity. Late June is the end of emergence of L. achine and O. tarpeja.

In early July, the imagoes of E. ligea, H. autonoe, C. briseis and C. persephone appear. At the end of July, C. hero, C. arcania, C. leander and C. persephone finish emerging. The majority of Satyridae of the region finish their emergence in August.

Being the only representative of the late summer phenological group, C. pamphilus emerges till the middle of September. During this period, the larvae of the first ecological group (spending winter in the larva stage) are actively feeding, preparing for the diapause.

By zonal distribution, the Satyridae of the studied region may be divided into three groups. The first group unites four species: H. lycaon, A. arethusa, O. tarpeja and M. russiae, wide-spread in all the three natural climatic subzones, the northern and southern forest-steppe, forb-bunchgrass steppe. The second group consists of the 16 species common only for the forest-steppe zone: L. achine, L. maera, L. petropolitana, C. tullia, C. hero, C. glycerion, C. arcania, C. pamphilus, M. jurtina, E. aethiops, A. hyperantus, M. dryas and C. briseis. Four of them, P. afra, E. medusa, C. arcania and C. briseis, populate the southern forest-steppe only; one — E. ligea is only found in the northern forest-steppe, and the rest 11 species live both in the northern and the southern forest-steppes. The third group consists of four species: C. leander, H. lupina, H. autonoe and C. persephone. The most favourable places for the life of this group are located in the forb-bunchgrass steppe occupying the south of the region.

By the landscape and biotopic allocation, the Satyridae of the region can be conventionally divided into four ecological groups: the inhabitants of the pine and small-leaved forests, the inhabitants of the forest-outlier and meadow landscape, inhabitants of the steppe-heaths and eurybiots.
The forest landscape consists of two main biotopes: the forest canopy and the open forest areas (edges of the forest, clearcuts). The greater population of the Papilionoformes including Satyridae is found in the open forest areas, which is explained by the better access of the sun and trophic connections of the larvae. In the pine and small-leaved forests, there are ten species: L. achine, L. maera, L. petropolitana, C. tullia, C. hero, C. glycerion, M. jurtina, E. ligea, E. aethiops, H. autonoe. Besides those listed above, there are species from other ecological groups found in the forest, such as O. tarpeja, coming here looking for forage plants.

The forest-outlier and meadow landscape encompasses three main habitat types: the forest-outlier canopy, the adjacent meadows and the grazing meadows. The forest outliers consist of birches and aspens. The group of insects inhabiting the forest-outlier and meadow landscape includes four species of Satyridae: C. leander, H. lupina, O. tarpeja and M. russiae. Besides, in this area some individuals of E. aethiops, M. jurtina, A. arethusa, C. briseis, E. medusa, C. glycerion, may emerge.

Steppes are more common for the south of the region. The species allocated to the steppe areas are P. afra, E. medusa, A. arethusa, C. briseis.

The group of eurybiots populating all main types of landscapes is represented by six species: C. arcania, C. pamphilus, H. lycaon, A. hyperantus, M. dryas and C. persephone.

The similarity of the species composition of the Satyridae inhabitant in the forest-outlier and steppe landscapes constitutes 53%. This is explained, first of all, by the prevalence of Poaceae being the fodder plants for the larvae of the majority of the family species. 43% is the similarity index of the species composition of the pine and small-leaved forests, as well as the forest-outlier and meadow landscapes. There is low similarity (28%) of species between the steppe and forest landscapes.

4. Conclusions
As a result of the study, the inhabitance of 24 species of the Lepidoptera of the Satyridae family in the South Trans Urals was confirmed.

96% of the Satyridae fauna of Kurgan Oblast consists of Palearctic species.

The Satyridae inhabitant in the region can be classified into two ecological groups: 19 species spending winter as larvae and two species spending winter as a pupa. For three species, C. hero, P. afra and C. persephone, the winter stage was not found.

Among the Satyridae of the South Trans Urals, there are both oligophagous and polyphagous species, with the first constituting 79% of the regional Satyridae population.

Based on the emergence timing, the imagoes of the Satyridae living in the region can be divided into three phenological groups: early summer (6 species), summer (15 species) and late summer (1 species).

Generally, the Satyridae fauna of the region can be referred to as inhabitant in the forest-steppe area. The Satyridae were found to inhabit the territory in an uneven manner. The greatest diversity of the species was found in the open space fauna (clearcuts and forest openings) of the pine and small-leaved forests.

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