[Diel activity rhythms of hoverflies (Diptera, Syrphidae) in the southern trans-Urals]

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Introduction

The study of the daily activity of insects makes it possible to distinguish groups with different rhythms of activity. The general classification of rhythms of insect activity is reflected in the works of V. B. Chernyshev [1, 2]. The author analyzed the causes of variations in these rhythms, which consist mainly of changes in either the physiological state of the insect or environmental conditions. In addition, the rhythms of insect activity significantly depend on the geographical latitude and altitude above sea level. There are no similar
works with respect to syrphids. The daily activity of hoverflies, namely the dependence of the flight of flies on climatic factors of the environment, has been studied by many [3-11]. These works show the influence of illumination, humidity, air temperature and wind speed on the activity of all hoverflies at the same time. However, the activity of flies of this family differs both at the generic and species levels, therefore, it is more correct to consider the influence of certain environmental factors on the flight of hoverflies separately in accordance with a certain rhythm. The identification of groups of hoverflies with different rhythms of activity was carried out in the territory of Lower Amur [4]. The author of this publication noted the different reactions of daytime and morning-evening hoverflies to the effects of climatic factors. In the conditions of Lower Amur, he attributed species from the genera *Platycheirus* and *Melanostoma* to morning-evening hoverflies, explaining such activity by the feeding of flies on anemophilous plants [4, 12].

For other territories, the activity of hoverflies has not been studied, and it is not clear whether the flight rhythms of species of this group are preserved, whether the hoverfly population as a whole changes over time, and what are the reasons for these changes. The aim of this work is to identify, in the conditions of the Southern Urals, groups of hoverflies with one or another rhythm of activity during the day. To solve it, the following tasks were set:
1) to study the dynamics of hoverfly flight in different seasons;
2) to identify the presence of ultradian periods;
3) to identify the similarity between different ultradian periods;
4) to determine the edificators of this similarity;
5) to identify the types of rhythms of hoverfly activity in the conditions of the Southern Urals.

Material & Methods

The results of daily counts conducted from May to September 2001-2002 in the Southern Urals were used to analyze the rhythms of syrphid activity. The Kurgan region occupies the largest part of the studied region. The Southern Urals includes the subtaiga belt of the Tyumen and Sverdlovsk regions, bordering the Kurgan region in the north [13].

The calculations were based on the data obtained from 28 daily counts. On average, 2-3 daily counts were conducted in each month using the methods of V. A. Mutin [6]. They are as follows:
1) on plants of a certain species, a permanent collector caught all anthophilic insects continuously, without removing them from the net individually, during the first 10 minutes of each hour during the daylight period, while the net was in a vertical position and the flies accumulated in the corner of the net;
2) from the flowers of plants of different species, as well as all those noticed among the grass, during the same time, a permanent collector caught only hoverflies.

The first method allows us to identify, in addition to the dynamics of insect flight during the day, the structure of the anthophilic complex of a certain plant species, but does not allow us to obtain reliable results regarding the nature of hoverfly flight during the day, since it is impossible to take into account all hoverfly species flying during this period on one plant species. The second method allows us to collect all hoverflies noticed from different plants in the entire survey area. The counting area is a strip of 100 m in length and 5-10 m in width among abundantly flowering herbaceous plants or shrubs.

In addition to the listed methods, an additional method of counting syrphids was used - sweep-netting all insects along the grass or flowering shrubs during the first 10 minutes of each hour during the daylight period of the day in a counting strip of the same size. When sweeping, 250 swings with a net were made. Insects were removed from the net after every 50 swings. This method allows us to count small dipterans, which are difficult to catch individually from flowers or plant leaves. A complete picture of the daily dynamics of syrphid flight can only be created by complex use of various counting methods.

Daily surveys were conducted in non-floodplain and floodplain wet meadows, in steppe, mesophytic (pin) meadows, in fallow lands and in gardens in the vicinity of the city of Kurgan, the village of Lisye (Lebyazhevsky district), the Iskra pasture (Zverinogolovsky district) and the Bogandinsky pasture (Tyumensky district). Anthophilous insects were collected from the following plant species during the daylight period: *Salix cinerea, Salix triandra, Caltha*

palustris, Ranunculus repens, Sisymbrium loeselii, Cerasus vulgaris, Filipendula vulgaris, Spiraea crenata, Euphorbia virgata, Cenolophium denudatum, Heracleum sibiricum, Seseli libanotis, Taraxacum officinale and *Tripolium pannonicum*. A total of 7,570 hoverfly specimens were collected and processed during the survey period.

Since hoverflies are diurnal insects, the term “diel rhythms" was used, which refers to rhythms lasting less than a day [14]. The boundaries of the diel periods were determined using the program for the classification of ordered objects [15]. The Jaccard coefficient modified by R. L. Naumov was adopted as a measure of similarity for quantitative characteristics [16]. Within each variant, there were 10-13 ten-minute segments of each hour (the total number of initial variants was 333). The initial variants of daily counts were averaged within three seasonal periods: May, June-July, and August-September. First, for each hour within these periods, chronologically ordered matrices of the similarity coefficients of the syrphid complexes were calculated separately. Then, the series of coefficients, without rearranging the variants in the series, was successively divided into two, three, etc. classes in such a way that the commonality within the classes was greatest and the similarity between them was least. In the calculations according to this program, similarity estimates are used not only between samples of adjacent chronological segments , but also of each sample with all the others in the analyzed series. This reduces the probability of drawing erroneous boundaries in the case of a sharp difference between two adjacent variants with a high similarity of the latter in a series of samples, i.e. with random, non-repeating differences in the series. The chronological series of syrphid complexes of each period is divided into six groups. Further division led to the isolation of individual samples as independent classes and is therefore considered inappropriate.

Dominant (predominant) species (dominants) were considered to be species whose abundance is more than 12% of the total [17]. The leading species (leaders) are the three most abundant species. Abundance (numerous) is the average number of individuals of a given species or group of species per unit of time (10 minutes of an hour) at the time of the study [18]. Species whose average abundance in terms of abundance is equal to or greater than one were considered background.

Mathematical processing of the materials was performed in the database of the Laboratory of Zoological Monitoring of the Institute of Ecology and Ecology of Animals SB RAS.

Results & Discussion

Boundaries of ultradian periods.

The first and most clearly expressed boundary of diel periods of hoverflies in June-July and in August-September occurs between 19:00 and 20:00, and in May shifted an hour earlier - between 18:00 and 19:00 (Table 1). In May, after 18:00, the abundance of *Chrysotoxum vernale*, *Syrphus ribesii*, *Eoseristalis arbustorum* and *Syritta pipiens* sharply increased. From June to September, the occurrence of the boundary after 19:00 is due to a change in the abundance, towards an increase in such species as *Platycheirus clypeatus*, *P. fulviventris*, *P. immarginatus*, *Melanostoma scalare* and *Sphaerophoria scripta*. After a significant daytime break, *Eoseristalis abusiva* and *Parhelophilus frutetorum* reappear.

[**Table 1**: Boundaries of the diel periods of the syrphid population of the Southern Trans-Urals]

The second significant boundary is the morning one, common for May and August-September, between 8 and 9 a.m. The indicator species in this case were *Melanostoma scalare, Platycheirus clypeatus, P. fulviventris, Sphaerophoria scripta, Chrysotoxum festivum* and *Eristalinus sepulchralis*. These species began to be encountered before 8 a.m., but their abundance increased significantly only after this time. In June-July the boundary is shifted an hour earlier and passes between 7 and 8 a.m. Its occurrence is caused by an increase in the number of *Helophilus hybridus* almost threefold (from 0.7 to 2.3 individuals/count).

The next most common boundary determines the middle of the day, and is usually accompanied by simultaneous changes in many species. In each season this boundary falls at a different time: in May, between 13 and 14 pm; in June-July, between 12 and 13; in August-September, between 11 and 12. In May, the manifestation of this daytime boundary was caused by a significant decrease in the number of *Melanostoma scalare*, *Syrphus ribesii*, *Cheilosia pubera* and *Eoseristalis interrupta*, and *Platycheirus angustatus* ceased to be encountered at all. At the same time, after 13:00, other species appeared in significant quantities - *Parasyrphus nigritarsis*, *Ceriana conopsoides*, *Eoseristalis pseudorupium*, *Myathropa florea* - and the abundance of *Dasysyrphus venustus* sharply increased (from 0.8 to 4 individuals/count). In June-July, this daily boundary is associated with a change in the composition of the syrphid population. After 12, *Scaeva pyrastri, Cheilosia fraterna, Anasimyia lineata* and *Pipizella viduata*, previously encountered in significant quantities, were not recorded. In addition, the abundance of such species as *Chrysotoxum festivum*, *Cheilosia lasiopa* and *Ch. vulpina* significantly decreased, but the abundance of *Ceriana conopsoides* increased. In August-September, the daytime boundary is associated with a significant reduction in the number of such species active in the early hours, such as *Chrysotoxum festivum*, *Platycheirus fulviventris*, *Sphaerophoria scripta*, *Helophilus hybridus* and *Eoseristalis anthophorina*. After 11 am, the abundance of *Syrphus ribesii*, *S. vitripennis*, *Eoseristalis arbustorum*, *Eristalis tenax* and *Syritta pipiens* increased.

In addition to the three main boundaries (morning, evening and daytime), in each season, less sharp boundaries were identified in the morning and evening, limiting the hourly interval. In May and in August-September, the morning boundary occurred at the same time - between 9 and 10 am. However, the ratio of syrphid species in

each of these periods is significantly different. In May after 9 am, the abundance of *Melanostoma scalare*, *Sphaerophoria scripta*, *Syrphus ribesii*, *Cheilosia pubera* and *Anasimyia interpuncta* increased significantly. Such previously abundant species as *Epistrophe nitidicollis*, *Eupeodes corollae* and *Eristalis tenax* were not recorded. In August-September, in contrast, the drawing of this boundary was due to a sharp decrease in the abundance of *Melanostoma scalare, Sphaerophoria scripta, Chrysotoxum festivum, Platycheirus clypeatus, P. fulviventris* and *Eristalinus sepulchralis*, but the abundance of *Myathropa florea* and representatives of the genus *Helophilus* increased significantly. In June-July, the boundary that separates late morning is shifted an hour earlier. It takes place between 8 and 9 a.m. and coincides with the first morning boundary of May and August-September. The indicator species of differences along this boundary can include *Chrysotoxum festivum*, the abundance of which increases significantly from 0.6 to 3 individuals/count, and somewhat less in *Eoseristalis arbustorum* from 0.6 to 1.2 individuals/count.

There is an additional gap that divides the evening into two segments - early and late evening. In May, the latter coincides with the first evening boundary and closes the period between 19 and 20 hours. After a certain daytime break, after 19 hours, *Melanostoma scalare, Chrysotoxum vernale, Eupeodes latifasciatus, Helophilus parallelus, Platycheirus peltatus, Malotta megilliformis* and *Neoascia tenur* appear again in large numbers. The June-July late evening boundary between 20 and 21 hours is characterized by the cessation of the flight of almost all hoverflies, with the exception of *Sphaerophoria scripta*. The evening boundary in August-September differs significantly in terms of passage time. It, like the daytime, is significantly shifted to an earlier time and is between 16:00 and 17:00. After 16:00, no representatives of the genus *Eupeodes* were found, the abundance of *Eoseristalis abusiva* and *E. arbustorum* noticeably decreased. At the same time, the number of *Syritta pipiens* doubled (from 3 to 6 individuals/count), representatives of the genus *Neoascia* became abundant, and after a significant period of absence, flies of the genus *Syrphus* were again significantly active.

Thus, the time of passage and the significance of the boundaries differ in spring, summer, and autumn. The boundaries of early morning and late evening in June-July are shifted to earlier and later hours in comparison with May and August-September, which is due to the lengthening of daylight hours and higher air temperatures. The period of daytime air warming in spring and autumn is extended, which affects the corresponding shift in time of morning and daytime activity of syrphids. Unlike the summer months, the boundaries of these periods are shifted to a later time, and the evening boundaries are passed much earlier. Significant differences in the passage of daytime boundaries are characteristic of August-September. The daytime period begins and ends earlier than in other months.

Despite the differences in the composition of species and their abundance ratio, the similarity of the boundaries of the diel periods of the syrphid population in the spring, summer and autumn periods is significant. Morning and evening boundaries are formed due to differences in the numbers and flight activity of such species as *Melanostoma scalare, Platycheirus clypeatus, P. fulviventris, P. immarginatus, Chrysotoxum festivum, Ch. vernale, Sphaerophoria scripta, Syritta pipiens* and *Helophilus parallelus*. Daytime boundaries are associated mainly with the appearance in significant numbers, and then a decrease in the activity of representatives of the genera *Eupeodes, Epistrophe, Eristalis, Myathropa, Ceriana* and *Cheilosia*. All this allows us to distinguish six diel periods for all seasons:

1) early morning;
2) morning;
3) late morning;
4) daytime;
5) evening;
6) late evening

(see Table 1).

[**Table 2**: Brief characteristics of the diel periods of syrphids in the South Urals
rows = daily periods (early morning, morning, late morning, daytime, evening, late evening)
cols = seasonal periods (May, June-July, August-Sept)
* the table shows the leading species (top 4 in abundance) on average for the period
**average total abundance (indivs/count); total number of spp recorded; number of background spp]

Quantitative characteristics of the diel periods of the syrphid population.

1. The **early morning period** is distinguished by the lowest indices of total abundance and species richness, including background (Table 2). The smallest number of species was found in May (4), the largest in August - September (13) (background - 6). In June-July, 8 species were recorded, of which 2 were background. The highest average total abundance is also characteristic of August - September (22 individuals/count), with significantly lower indicators noted for June - July and May (2 individuals/count). In May, only single specimens were found. In June-July, *Helophilus hybridus* and *Eoseristalis arbustorum* dominated, accounting for 57% of the total abundance of hoverflies. In August-September, these were *Sphaerophoria scripta*, *Platycheirus fulviventris, P. clypeatus* and *Eristalinus sepulchralis*, together making up 86% of the population.

2. The **morning period** is characterized by an increase in the activity of hoverflies, with a sharp increase in the number of species noted and the total abundance (see Table 2). The species composition became richer in all seasons. In general, from 20 to 30 species were noted in each of them. The total abundance increased by 3-5 times compared to the previous period. In May, the leading species were those that were encountered singly in the early

morning - *Melanostoma scalare, Syrphus ribesii* and *Helophilus parallelus* is again included in this number. They accounted for 45% of the total abundance. Among the named species, *Melanostoma scalare* dominated (16%). In June-July, the dominant species, as in the early morning period, included *Helophilus hybridus*, and from the Eristalinae *Eoseristalis abusiva* and *Eristalinus sepulchralis*. Together, they accounted for 56% of the total abundance. The composition of the dominant species in August-September is similar to that in the previous period. Together with hoverflies of the genera *Sphaerophoria* (45%) and *Platycheirus* (32%), *Chrysotoxum festivum* (5%) prevailed. In this season, the number of background species increased by 2.3 times, in May by three times, in June-July by only 1.5 times.

3. The **late morning period** is characterized by an even greater diversity of the species composition of hoverflies and a twofold increase in the total abundance in May and in June-July. In August-September, with a one and a half-fold increase in the number of species (from 30 to 42), the number of hoverflies decreases from 62 to 53 individuals / census. This decrease continued later, as did the number of background species, i.e. for the autumn season, the maximum number of hoverflies is characteristic of the morning period. This can be explained by the fact that in August-September the bulk of species ceased to be encountered, and the abundance of such summer-autumn and polyseasonal hoverflies as *Platycheirus clypeatus*, *P. fulviventris*, *Sphaerophoria scripta* and *Chrysotoxum festivum* increased significantly. The number of species in May increased 2.3 times. *Melanostoma scalare* (22% of the total abundance), *Sphaerophoria scripta* and *Cheilosia pubera* (14 and 12%, respectively) continued to dominate. In June-July, the species richness increased threefold compared to the previous period (from 20 to 60). During the summer and autumn seasons, *Chrysotoxum festivum* (19 and 8% of the total abundance, respectively, in June-July and August-September) and *Helophilus hybridus* (11 and 7%) were in the lead. In June-July, in addition to the named species, the leaders include *Myathropa florea* and *Eristalinus sepulchralis*, whose share was 13% of the population. In addition, it is necessary to note the appearance from 9 a.m. of representatives of the genera *Eupeodes*, *Epistrophe*, *Cheilosia*, *Eristalis*. In August, as in May, *Sphaerophoria scripta* (24%) and *Helophilus parallelus* (7%) were in the lead.

4. The **daytime period** is distinguished by the maximum diversity of species in all seasons. The number of background species almost doubles in May alone (from 7 to 13). The total abundance on average for the period changed slightly - from 19 to 20 individuals/count. At the same time, as in June-July and in August-September, against the background of an increase in the total number of species, the number of hoverflies decreased by 1.5 times, and the number of background species - by 1.2-1.5 times. Subsequently, the total abundance, the number of species and the number of background species from June to September continued to decrease. In this period in May, the leaders still include *Sphaerophoria scripta* (11%) and *Melanostoma scalare* (10%), as well as *Dasysyrphus venustus* (10%) and *Anasimyia interpuncta* (8%). In August-September, *Sphaerophoria scripta*, *Eristalinus sepulchralis* and *Syritta pipiens* acted in this capacity, among which, as in May, *Sphaerophoria scripta* dominated (28%). *Eristalinus sepulchralis* and *Syritta pipiens* together accounted for 19% of the total abundance. The last two species were also in the lead in June-July (21%). Among the eristalinae, *Eoseristalis abusiva* (17%) prevailed in June-July, and *Eoseristalis arbustorum* (11%) in August-September. *Helophilus hybridus* acted as the dominant for June-July, which also led in all the above-mentioned periods. It accounted for 12% of the total abundance. It should be noted that in June-July only at this time such species appeared as *Epistrophe diaphana* (Ztt. 1843), *Leucozona laternarius* and *Lejops vittatus*.

5. The **evening period** is distinguished by a significant reduction in the total and background number of species, as well as in the total abundance. A particularly sharp decrease in these indicators is noted in June-July. The number of species decreases almost 7 times (from 68 to 10), and the abundance - 6 times (from 11 to 2). *Helophilus hybridus* (30%) continues to dominate, joined by *Sphaerophoria scripta* (45%). It should be noted that the latter species was the leader only in June-July, while in August-September it was constantly dominant, and in May - only during the daytime. In May, the number of species in this period compared to the previous one decreased by 4 times (from 55 to 13), the abundance - by 1.4 times (from 20 to 14 individuals / count) and the number of background species decreased almost three times (from 13 to 5). *Chrysotoxum vernale* and *Syrphus ribesii* again acted as dominant species, which prevailed in the morning periods as well. They accounted for 29% of the total abundance. In addition to them, *Eoseristalis arbustorum* also dominated (21%), and *Syritta pipiens* (7%) also entered the list of leaders. For August-September, the parameters under consideration are half as much. The composition of the leading species changes insignificantly. In addition to the dominants of the previous period (*Sphaerophoria scripta*, *Syritta pipiens* and *Eristalinus sepulchralis*), which account for 63% of the total abundance, *Helophilus parallelus* (8%) was added.

6. The **late evening period** is characterized by a depletion of species composition in August-September (from 26 to 11) and especially in June-July, when only one species remains active - *Sphaerophoria scripta*. The leading species in August-September change significantly. Only *Sphaerophoria scripta* continued to prevail (29%), otherwise, as in the morning hours, hoverflies of the genus *Platycheirus* led . They account for 47. % of the total abundance. In May, this period of time was distinguished by a twofold increase in the
total number of species, while the total abundance decreased by 1.4 times. The share of the dominant species of the previous period - *Chrysotoxum vernale* increased at this time and amounted to 25% of the total abundance. The composition of the remaining leaders changed. These included *Melanostoma scalare* (13%), which was dominant in almost all periods, *Helophilus parallelus* (10%), dominant in the morning, and *Neoascia tenur* (7%), which was noted for the first time as a leader.

Thus, the boundaries of the diel periods of the syrphid population largely coincide in May and August-September, despite significant differences in the population. The same periods differ in duration and start time in June-July. From May to September, there was a gradual change of syrphid complexes during the day, although each diel period was characterized by the same dominants. At the same time, in all seasons, the population of the morning and evening hours is most similar. Graphically, the intra-day change of syrphid complexes can be represented as a tilted flask (Fig. 1). In its rounded part there is a chain of successively different complexes of hoverflies flying in the late morning and afternoon. In its close parts along one arc there are morning complexes, along the other - evening ones. Thus, the greatest similarity of the species composition and abundance of hoverflies was observed in the early morning and late evening with a comparatively small abundance of hoverflies, and the periods of the remaining morning and evening hours and daytime are less similar.

[**Figure 1**: Diel periods of the syrphid population in the conditions of the Southern Trans-Urals.
The numbers indicate the hours, the names of the daily periods are given near the diagram]

[**Figure 2**: Dependence of the activity of syrphids of some genera and species on the time of day.
a: 1 = *Chrysotoxum*, 2 = *Helophilus*, 3 = *Cheilosia*; b: 4 = *Myathropa florea*, 5 = *Eupeodes*.]

Diel activity rhythms of syrphid activity

The period of daily activity of most syrphid species lasts from 8 to 20 hours. However, the peak of the population of each of them falls on a certain period. Based on the three main diel boundaries and the similarity of the population between periods, four rhythms of activity of hoverflies have been identified: morning, day, evening and morning-evening.

The maximum activity of hoverflies with a morning rhythm falls on average at 9-12 o'clock. This type is characteristic of hoverflies of the genera *Chrysotoxum*, *Cheilosia*, *Helophilus*, *Eupeodes*, and also *Myathropa florea* (Fig. 2). Representatives of the genus *Chrysotoxum* can be called typical morning species. The abundance of hoverflies of this genus at 9-10 am significantly exceeded that in the following hours, when flies were encountered singly. The other listed genera are characterized by a slight increase in numbers in the second half of the day - from 3 to 5 pm. Within the genus *Helophilus*, the greatest activity in the second half of the day is characteristic only of *H. parallelus* - at 3 pm.

The diurnal species include hoverflies, the maximum numbers of which were observed in the second half of the day - on average from 12 to 4 pm. These are representatives of the genera *Eristalis*, *Dasysyrphus* and *Eristalinus sepulchralis*, the period of activity of which extends from 10 to 4 p.m., as well as *Ceriana conopsoides* and hoverflies of the genera *Xylota*, *Neoascia*, most abundant at 12-1 pm (Fig. 3). It should be noted that in the Lower Amur region, the activity of flies of genera such as *Xylota* and *Neoascia* occurred at 12-13 pm [4]. Among the listed hoverflies, the shortest flight period - 8-9 hours - is characteristic of *Xylota* and *Ceriana conopsoides*, while the rest had a flight duration of about 13 hours. Although most Eristalinae have a diurnal rhythm, species such as *Eoseristalis anthophorina* and *Eristalis tenax* are most active between 9 and 12 am. Their maximum abundance was recorded at this time, after which their numbers noticeably decreased.

Some species of hoverflies showed a morning-evening rhythm of activity. Such hoverflies had two peaks of abundance - in the morning and in the evening (*Platycheirus*, *Melanostoma*), or three - the main two in the morning and in the evening and a small third in the daytime. The latter rhythm of activity is characteristic of representatives of the genera *Syrphus*, *Anasimyia*, *Parhelophilus* and *Volucella*, as well as *Episyrphus balteatus* and *Sphaerophoria scripta* (Fig. 4, 5). Despite the fact that the periods of increase in the abundance of these hoverflies do not coincide somewhat, for almost all of them the greatest abundance occurs in the morning (from 9 to 12 am) and evening (from 17 to 21 pm). However, *Sphaerophoria scripta* and hoverflies of the genus *Parhelophilus* are maximal after the morning rise between 15 and 17 h. In contrast, in the conditions of the Lower Amur region, representatives of the genus *Syrphus* were abundant during the daytime (10-13 h).

The earliest and latest time of activity is characteristic of *Platycheirus* and *Melanostoma*. The morning-evening rhythm of hoverflies of these genera is explained by the diet of most species, the basis of which is the pollen of anemophilous plants [4,12]. The anthers of such plants (sedges and cereals) open in the morning hours, and the high humidity of the pollen in the morning and evening, according to these authors, contributes to an increase in the attractiveness of the pollen for syrphids at this time. In our studies, the daily population dynamics of *Platycheirus* and *Melanostoma* turned out to be different in wet floodplain meadows in May and in non-floodplain meadows in August, although the activity of hoverflies in these seasonal periods is largely the same (Fig. 6). In the floodplain meadow in May, hoverflies were collected from marsh marigold flowers, and in August from forbs, including marsh rushes (*Eleocharis palustris*: Cyperaceae). Probably, the activity of hoverflies depends largely on the flowering time of all food plants, and not just sedges.

[**Figure 3**: Dependence of the activity of syrphids of some genera and species on the time of day.
a: 1 = *Eristalis*, 2 = *Eristalinus sepulchralis*, 3 = *Dasysyrphus*; b: 4 = *Neoascia*, 5 = *Xylota*, b = *Ceriana conopsoides*.]
[**Figure 4**: a: 1 = *Platycheirus* + *Melanostoma*, 2 = *Syrphus*, 3 = *Episyrphus balteatus*; b: 4 = *Anasimyia*, 5 = *Volucella*, b = *Parhelophilus*]
[**Figure 5**: Dependence of the activity of Syritta pipiens (1) and Sphaerophoria scripta (2) on time of day]

[**Figure 6**: Dependence of the activity of *Platycheirus* and *Melanostoma* on time of day in wet non-floodplain (1) and wet meadows of river floodplains (2)]
[**Figure 7**: Dependence of the activity of *Epistrophe* (1) and *Mallota* (2) on time of day]

It should be noted that, despite the morning-evening rhythm of activity of representatives of the genus *Volucella*, the maximum number of different species was observed at different times. Thus, *V. bombylans* was found in greater numbers from 8 to 9 am, while *V. pellucens* was more abundant in the evening - from 4 to 6 pm. *V.bombylans* in the Lower Amur region was also noted early - 5:30 am [4].

One species is known with an evening rhythm of activity in the Southern Urals - *Syritta pipiens*. The total duration of the flight of flies of this species was 12 hours (see Fig. 5). From 9 am to 1 pm the abundance of this species gradually increased, then, after a general decline in numbers, it sharply increased and reached its maximum value at 5 pm. This is the time of the evening activity period in August-September, when *Syritta pipiens* was numerous.

It should be noted that there is an abrupt change in the daily activity of the hoverflies of the genera *Epistrophe* and *Mallota* (Fig. 7). *Epistrophe* appeared throughout the entire daylight hours only in three time intervals - at 9 am to 11 am, 1 pm to 3 pm, and 5 pm to 7 pm. No flies were encountered in the intermediate hours. The total duration of the flight of *Epistrophe* was 11 hours. Representatives of the genus *Mallota* are generally characterized by a 14-hour flight period - from 8 am to 9 pm. During this period, the hoverflies were active at a certain hour. The diel cycle of syrphids of this genus takes the form of a five-peaked curve (see Fig. 7). A feature of *Mallota* activity is the appearance of flies late in the evening - at 9 pm, after a three-hour break.

Conclusions

1. In the spring-summer period, regardless of the month, syrphid complexes change in time.
2. Three main boundaries of the diel periods of syrphid flight were obtained - morning, evening and daytime. Additional boundaries that divide morning, day and evening into two segments led to the identification of six diel periods.
3. In the spring, summer and autumn seasons, the passage time and significance of the boundaries differ, and differences are also observed in the composition of hoverfly species and the ratio of their numbers. Despite this, the similarity between the boundaries of the diel periods of the hoverfly population in the spring, summer and autumn periods is significant.
4. The indicator species of the difference between the morning and evening boundaries were *Melanostoma scalare*, *Platycheirus clypeatus*, *P. fulviventris*, *P. immarginatus*, *Chrysotoxum festivum*, *Ch. vernale*, *Sphaerophoria scripta*, *Syritta pipiens* and *Helophilus parallelus*. The daytime boundaries are associated with an increase and then a sharp decrease in the number of representatives of the genera *Eupeodes*, *Epistrophe*, *Eristalis*, *Myathropa*, *Ceriana* and *Cheilosia*.
5. The greatest similarity in the species composition and abundance of hoverflies was observed in the early morning and late evening, less similar were the periods of the remaining morning and evening hours and daytime.
6. Based on the significant diel boundaries of the hoverfly flight periods and the similarity between the periods, four rhythms of hoverfly activity were identified: morning, daytime, evening and morning-evening. Hoverflies of the genera *Epistrophe* and *Mallota* are characterized by a distinctly jerky pattern of activity during the day (cf. Fig 7).