

Rhythms of diel activity of coprophilous beetles of mountain pastures

Ритмы суточной активности копрофильных жесткокрылых горных пастбищ

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КЛЮЧЕВЫЕ СЛОВА: горные пастбища, копрофильные насекомые, Coleoptera, ритмы активности.

ABSTRACT: Here we report on the results of studying the rhythms of activity of coprophilous beetles (Staphylinidae, Scarabaeidae, Hydrophilidae, Histeridae) on pastures of the Gorny Altai. Temperature conditions have been proved to be a determinant factor of the beetles' diel rhythms. Differences in types of the activity of Coleoptera become apparent on genus and species levels. The main number of species has diurnal rhythm of activity with one peak at midday at the temperature range from 23 up to 26°C. The temperatures over 28°C and lower depress their flight activity and general locomotion of the beetles on the substratum.

РЕЗЮМЕ: Приведены результаты изучения ритмов активности копрофильных жесткокрылых (Staphylinidae, Scarabaeidae, Hydrophilidae, Histeridae) на пастбищах Горного Алтая. Выявлено, что определяющим фактором суточной ритмики является температурный режим. Основная масса видов имеет дневной ритм активности с одним пиком в середине дня в интервале температур от 23 до 26°C, значения температуры выше 28°C и ниже 15°C угнетают летную активность и общую локомоцию жуков на субстрате. Для поддержания активного состояния жесткокрылые используют микроклиматические особенности субстрата, совершая вертикальные миграции.

Introduction

Regular changes in the most important abiotic factors environment occur within a day, producing responses in organisms, and appear in alternation of different types of activity and the period of a relative rest. Such diurnal rhythms with differing degree of precision are found in all the groups of coprophilous insects. The study of dynamic changes, occurring in dung during the day, is important for an understanding of processes

developing in community of dropping and all ecosystem of pasture as a whole.

The community of dung-inhabiting beetles is rich in species. In the literature there Only fragmentary data about diurnal activity of some species of coprophilous Coleoptera are published [Tikhomirova, 1967; Yablokov-Khinzoryan, 1967; Protsenko, 1976; Kryzhanovskiy, 1976; Summerlin et al., 1993; Sowig, 1995, et al.]. We have been studying ecological particularity and the entomofauna of dung on mountain pastures for several years.

In the present paper, data on diurnal activity of adult beetles inhabiting cow and horse dung in Gorny Altai, including Staphylinidae, Scarabaeidae, Hydrophilidae and Histeridae, are provided. Different types of pastures (mountain-forest, mountain-prairie ones mainly) of miscellaneous high-altitude zones (up to 2500 m above sea level) have been investigated. It can be judged about activity of beetles by the intensity of flight within day and degree of their mobility on substrate. Diurnal rhythm has been studied by means of modified window traps installed above the substrate; the behavior of beetles on the substrate has been observed on special locality on pasture.

Results and Discussion

The results have shown that the general character of flight activity of the beetles depends on the type of dung and biotope a little and varies during a pasture season insignificantly. In spring and autumn diurnal activity decreases due to low temperatures in the morning, evening and especially at night. Temperature frequently fall up to 0°C and is lower, ground frosts and snow result in essential changes in a diurnal rhythm of coprophilous beetles.

Differences in types of activity of Coleoptera are shown on genus and species levels. The majority of species have diurnal rhythm of activity with one peak at midday at the temperature range from 23 up to 26°C. The temperature over 28°C depresses the flight activity and general locomotion of the beetles on substrate (Fig. 1).

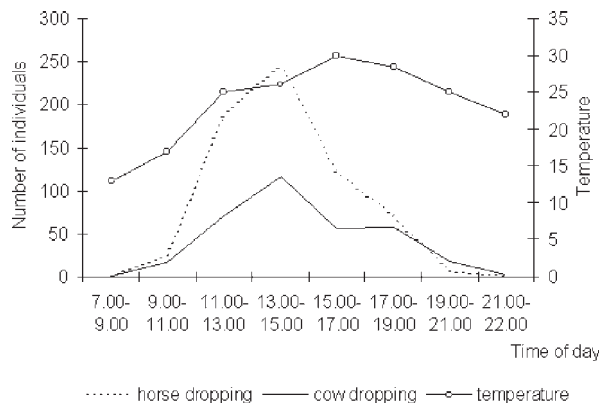


Fig. 1. General dynamics flight activity beetles on a dropping one-day age (Central Altai, August, 800 m a. s. l.).

Рис.1. Общая динамика летной активности жесткокрылых на помете однодневного возраста (Центральный Алтай, август, 800 м над у.м.).

At 30–32°C their flight ceases. Most of the species begin their flight at 13–15°C. At the temperature of nearly 10°C and lower, and high humidity (common for June) the beetles are slow-moving. They are located in the center of the substrate or in the soil under dropping.

Data on the number of some species of coprophilous beetles on different substrates within a day are showed in Tables 1 & 2. These data are based on results of the account of the number of individuals by window traps and allow to judge about variations of activity rhythms of genus and species within families..

Hydrophilidae. *Sphaeridium* spp. (*Sphaeridium substriatum* (Fald.), *S. bipustulatum* (F.), *S. scarabaeoides* (L.)) are thermophilic heliophilous, the most active in hot sunny weather. In some cases their total number in the traps varied from 12.00–15.00 to 200 individuals. *Sphaeridium* spp. are active within the substrate even at its temperature of 28.5°C. *Pachystrum haemorrhoum* (Motsch.) has the similar flight activity. Apparently for *Cercyon* spp. (*Cercyon melanocephalus* (L.), *C. quisquilius* (L.), *C. lateralis* (Marsh.) et al.), *Cryptopleurum minutum* (F.) lengthy activity with morning and evening fight peaks is characteristic. Obviously, under favourable temperature conditions these species are active at dusk and early night, since *Cercyon* spp. were repeatedly attracted by ultra-violet light. This supposition is favoured by a great number of *Cercyon* spp. and *Cryptopleurum minutum* in the substratum combined with small diurnal flight intensity.

Histeridae (*Hister sibiricus* (Mars.), *Margarinotus ventralis* (Mars.), *Atholus bimaculatus* (L.), *A. duodecimstriatus* (Schränk.) et al.) have strictly diurnal type of activity. Coprophilous histerids are termophilic, therefore they are most active at midday and afternoon time on pasture fields with great insolation. However at a high temperature of the substratum they tend to move into the layers with suitable temperature conditions — often to the “dung-soil” border, sometimes into the upper-soil layers the substratum.

Scarabaeidae are active during the bright day with the greatest flight intensity from 11.00–15.00. The exception is mesophilic *Geotrupes baicalicus* (Rtt.), which flies mostly at dusk and in the first half of the night. The first individuals of scarabaeids fly to fresh dung from 10.00 to 17.00–18.00 in May or in the beginning of June in clear sunny weather at the temperature of 16–18°C. In the substratum their activity can last 21.00. In June–August at optimum temperatures *Aphodius* spp., *Onthophagus* spp. fly from 9.00 to 21.00. They remain active in thick layers of the substratum after 21.00. Separate individuals of some species (*Aphodius rectus* (Motsch.), *A. rufipes* (L.), *A. immundus* (Cr.)) fly at dusk to the light of an ultra-violet lamp. In the beginning of August afternoon air temperature sometimes rises up to 30–32°C, the temperature of the surface dung being 37.5–41°C, which is pernicious for scarabaeids. At this time the beetles do not fly and migrate into deep layers or are in the soil under the substratum. At the air temperatures of 25–26°C in the daytime *Aphodius* spp. are active not only in the dung, but also on its surface, where they couple. Regardless of temperature, having found dropping, *Onthophagus* spp. bury themselves in the soil under a pat, where to feed and lay eggs.

The diurnal rhythm of coprophilous **Staphylinidae** is subjected to the influence of constantly varying conditions of a specific day. Due to high mobility and a reticent way of life it is rather difficult to distinguish a certain type of activity in this group. To define the activity characteristics of staphylinids we used the previously accepted intensity of their flight within a day and a relative number of mobile individuals in the substratum at the given period of time.

The flight dynamics of staphylinids is characterized by diurnal activity with the peak at 13.00–16.00 at the air temperature up to 26°C, and two peaked curves (11.00–13.00, 16.00–17.00) at the temperature of over 28–30°C. The activity connected with the substratum can be directly watched only in the beginning of its existence, when there are eggs and fly imago on the surface. The behavioral acts in this case consist in copulation, search of food, and attacks on coprophilic flies. Staphylinids appear on the surface of 3-days-old dung seldom and accidentally. This time one can judge their activity after breaking the dropping. In this case the reason for the observed locomotion can be not only feeding or breeding activity, but also a response to the destruction of the substratum, as geotropism is characteristic for staphylinids. Therefore, the activity evaluation of staphylinids according to the visible motive acts, especially in the morning and evening periods is relative enough. Hence, we define the diurnal activity of coprophilous staphylinids as a lengthy diurnal one with a midday increase.

Among staphylinids the most mobile are predatory *Ontholestes murinus* (L.), *O. tessellatus* (Four.), *Philonthus* spp., *Aleochara* spp. A high level of their movement activity is a condition of their normal habitability. The flight of these beetles in sunny weather begins at about 9.00 and lasts till 19.00–20.00. In morning hours

Table 1. Dynamics of flight activity of some Coleoptera on the cow dung one-day age (Central Altai, August, 800 m a. s. l.).

Таблица 1. Динамика летной активности некоторых Coleoptera на коровьем помете однодневного возраста (Центральный Алтай, август, 800 м над у.м.)

Coleoptera	Number of individuals within day							
	7.00– 9.00	9.00– 11.00	11.00– 13.00	13.00– 15.00	15.00– 17.00	17.00– 19.00	19.00– 21.00	21.00– 22.00
SCARABAEIDAE								
<i>Aphodius erraticus</i> Linnaeus, 1758		5	26	20	7	3		
<i>A. haemorrhoidalis</i> Linnaeus, 1758				1				
<i>A. pusillus</i> Herbst, 1789			1			1		
<i>A. depressus</i> Kugelann, 1798				1				
<i>A. foetens</i> Fabricius, 1787				1				
<i>A. rectus</i> Motschulsky, 1866							1	
<i>Onthophagus gibbulus</i> Pallas, 1781			2	6	9	5		
<i>O. laticomis</i> Gebler, 1823			1	1		2	1	
<i>O. fracticomis</i> Preyssl, 1790			7	13	6	4		
HYDROPHILIDAE								
<i>Sphaeridium scarabaeoides</i> Linnaeus, 1758		2	4	20		4	1	
<i>S. lunatum</i> Fabricius, 1792			2	2	5	1		
<i>S. bipustulatum</i> Fabricius, 1781		1	1	7	3	1		
<i>Cercyon</i> spp.		1	5			5	1	2
<i>Pachystemum haemorrhoum</i> Motschulsky, 1866			1	13	2	7	1	
<i>Cryptopleurum minutum</i> (Fabricius, 1775)		2	1		4	2	2	
STAPHYLINIDAE								
<i>Ontholestes murinus</i> Linnaeus, 1758		1	3	5	2	1		
<i>Philonthus marginatus</i> Stroem, 1786		1	4	3	2	1		
<i>Ph. splendens</i> Fabricius, 1792			3	1		1	2	
<i>Ph. rectangulus</i> Sharp, 1874						1		
<i>Ph. varians</i> Paykull, 1789					1	1	2	
<i>Ph. politus</i> Linnaeus, 1758					1	1		
<i>Ph. albipes</i> Gravenhorst, 1802				1	1	1		
<i>Ph. sanguinolentus</i> Gravenhorst, 1802					1		1	
<i>Ph. cruentatus</i> Gmelin, 1790		3	3	7	3	7	1	
<i>Ph. agilis</i> Gravenhorst, 1806			1	3	3	1		
<i>Platystethus cornutus</i> Gravenhorst, 1802			2	4	1	1	1	
<i>P. arenarius</i> Fourcroy, 1785				5	2	1		
<i>Oxytelus laqueatus</i> Marsham, 1802			3	2	1	1	2	
<i>O. hamatus</i> Fairmaire, 1854						2	2	
<i>Aleochara intricata</i> Mannerheim, 1830						1		
<i>Atheta</i> spp.						2		
HISTERIDAE								
<i>Atholus bimaculatus</i> Linnaeus, 1758				1				
PTILIIDAE								
<i>Acrotichis</i> sp.					2			

Table 2. Dynamics of flight activity of some *Coleoptera* on the horse dung one-day age (Central Altai, August, 800 m a. s. l.).Таблица 2. Динамика летной активности некоторых *Coleoptera* на конском помете однодневного возраста (Центральный Алтай, август, 800 м над у.м.)

Coleoptera	Number of individuals within day							
	7.00– 9.00	9.00– 11.00	11.00– 13.00	13.00– 15.00	15.00– 17.00	17.00– 19.00	19.00– 21.00	21.00– 22.00
SCARABAEIDAE								
<i>Aphodius erraticus</i> Linnaeus, 1758		2	3	8	2	1		
<i>A. rectus</i> Motschulsky, 1866		8	25	26	10	2	1	
<i>A. sabulicola</i> Thomson, 1868			1	2	1			
<i>A. foetens</i> Fabricius, 1787				1	1			
<i>Onthophagus fracticornis</i> Preyssler, 1970		1	10	5	6	6		
<i>O. laticornis</i> Gebler, 1823			1	3	1			
<i>O. gibbulus</i> Pallas, 1781		1	4	5	2	1		
<i>Geotrupes baicalicus</i> Reitter, 1893								1
HYDROPHILIDAE								
<i>Sphaeridium scarabaeoides</i> Linnaeus, 1758		1	21	24	15	11		
<i>S. lunatum</i> Fabricius, 1792			5	5	2			
<i>S. bipustulatum</i> Fabricius, 1781		4	58	93	13	6		
<i>Pachystemum haemorrhoum</i> Motschulsky, 1866		1	12	8	2			
<i>Cryptopleurum minutum</i> (Fabricius, 1775)		1	3	4	5	4		
<i>Cercyon</i> spp.			5		1	3	3	
STAPHYLINIDAE								
<i>Ontholestes murinus</i> Linnaeus, 1785		1	2	5	3	1		
<i>Philonthus cruentatus</i> Gmelin, 1790		1	9	14	6	8	1	
<i>Ph. splendens</i> Fabricius, 1792			2	2				
<i>Ph. sanguinolentus</i> Gravenhorst, 1802			1	2	1	1		
<i>Ph. marginatus</i> Stroem, 1786		3	5	2	1	1		
<i>Ph. albipes</i> Gravenhorst, 1802			1	8	6			
<i>Ph. varians</i> Paykull, 1789			8	13	5	5	1	
<i>Ph. rectangularis</i> Scharp, 1874				1	2			
<i>Ph. agilis</i> Gravenhorst, 1802			2	5	5	2		
<i>Platystethus cornutus</i> Gravenhorst, 1802			5	7	10	3		
<i>P. arenarius</i> Fourcroy, 1785			2	13	3	8	1	
<i>Oxytelus hamatus</i> Fairmaire, 1854				1		4		
<i>Aleochara milleri</i> Kraatz, 1862				3				
<i>A. intricata</i> Mannerheim, 1830						1		
<i>Atheta</i> spp.				5	10	2		
HISTERIDAE								
<i>Hister sibiricus</i> Marseul, 1854			1	2				
<i>Atholus bimaculatus</i> Linnaeus, 1758				1				
PTILIIDAE				1				
<i>Acrotrichis</i> sp.				4	10			

the air temperature can be some grades lower than the optimum, but the upper layers of the substratum warming up quickly contribute to increasing the temperature of staphylinids initiating their flight activity. Connections with a specific amount of dropping within a day for the species of *Ontholestes* spp., *Philonthus* spp. are not steady. They can escape it for 2–3 minutes and return, or fly away looking for another pat suitable for colonizing. At a high air temperature their flight ceases, however the beetles of these genera remain active on the surface and in deep layers of the dung. *Ontholestes* spp. hunt *Diptera*, *Philonthus* spp. and *Aleochara* spp., run across the surface now and then bending their bellies upwards and hide in a chink of the substratum. The species of *Oxytelus*, *Platystethus* feed in the thickness the dropping and seldom appear on the surface, running quickly from one chink to another. The flight dynamics of *Oxytelus*, *Platystethus* is similar to that of *Ontholestes* spp. and *Philonthus* spp., but is longer in the evening, as *Oxytelinae* are more coldphilic, than *Staphylininae*. The flight of *Platystethus cornutus* (Grav.) towards a substratum scent was observed in rain at the air temperature of 15.5°C.

The activity of some Staphylinidae continues after sunset up to dusk. Observing some cow dropping from 21.00 (air temperature — 22°C, surface of the substratum — 23°C, at the depth of 5 cm — 25°C) till 22.00 (19.5°C; 19°C; 20°C accordingly) within an hour we noticed the surface crossed 12 times by *Philonthus marginatus* (Stroem.), 8 *Ph. splendens* (F.), 2 *Ph. politus* (L.), 1 *Ontholestes murinus* (L.), 2 *Aleochara* sp. The flight of several individual *Platystethus cornutus* was observed. In the depth of the substratum at that time all the Staphylinidae were active — *Aleocharinae* gen. sp., small-sized *Philonthus* spp. (*Ph. lepidus* (Grav.), *Ph. agilis* (Grav.), *Ph. cruentatus* (Gmel.), *Ph. albipes* (Grav.)), *Oxytelus* sp., *O. piceus* (L.), *Platystethus arenarius* (Four.), and also *Aphodius* spp., *Onthophagus* spp. (*Scarabaeidae*). At 23.00 (temperature is 12°C; 12°C; 11.5°C accordingly) the activity of *Philonthus* spp. was depressed, they moved slowly after disturbing

the dung structure had been broken. *Platystethus arenarius*, *P. cornutus*, *Oxytelus* spp., and *Aleochara* sp. were more mobile. At a rather high air temperature at dusk and in the first half of night (with the temperature of nearly 20°C) some species of coprophilous staphylinids (*Philonthus cruentatus*, *Oxytelus piceus*, *Platystethus cornutus*, *P. arenarius*, etc.) fly towards the light of a ultra-violet lamp.

Thus, the leading factor determining diurnal activity rhythms of coprophilic beetles in the mountains, is air temperature. Due to low average diurnal temperatures the activity of the majority of species removes to mid-day, when the air temperature is 23–26°C. Only a small number of species fly at the temperature below 15°C. For keeping their active state the beetles use microclimatic conditions of the substratum migrating vertically. Such shifts let them find dung layers with the optimum temperature in the given period of day.

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