

## Succession in a insects community inhabiting horse dung

### Сукцессии в сообществе насекомых, населяющих помёт лошадей

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KEY WORDS: coprophilous insects, successions.

КЛЮЧЕВЫЕ СЛОВА: копрофильные насекомые, сукцессии.

**ABSTRACT:** The results of studying the succession in the community coprophilous insects on horse dung are reported. The general nature of the succession of adult insects on dung depends little on type pastures. The rate of successional changes depends on the biotopic conditions, the most important of which are temperature and moisture, and weather conditions. When comparing succession in horse dung with the similar processes in cow dung some differences in the species composition and in rate of these changes can be clearly seen. The dynamics of the numbers of individual species is determined by physical peculiarities of the substrate and chronologically is more prolonged. In contrast to cow dung, where Sepsidae and Muscidae are dominant from the first hours of its existence, horse dung is mainly inhabited by Sphaeroceridae, Anthomyiidae and Sarcophagidae. Horse dung, due to its substrate peculiarities, is used for a longer time by flies for feeding than is cow dung, and is characterized by a greater compactness and higher density of Coleoptera at all stages of succession.

**РЕЗЮМЕ:** Изучали сукцессию копрофильных насекомых в конском помете. Установлено, что характер сукцессии мало зависит от типа пастбища. Скорость сукцессионных изменений определяется биотопическими условиями, из которых наиболее важны температура и влажность, а также погодными условиями. Сравнивая сукцессию в конском помете с подобными процессами в коровьем, можно отметить некоторые отличия в видовом составе насекомых и в скорости происходящих изменений. Динамика численности отдельных видов определяется физическими особенностями субстрата и хронологически более растянута. В отличие от коровьего помета, где с первых часов его существования доминируют Sepsidae и Muscidae, на конском преобладают Sphaeroceridae, Anthomyiidae, Sarcophagidae. Конский помет из-за особенностей его структуры, более длительное время используется мухами для питания, чем коровий и характеризуется большей плотностью и численностью Coleoptera на всех стадиях сукцессии.

### Introduction

The insect community in dung, as with any community of organisms, is dynamic over time. One manifestation of such dynamics is the successional changes that take place in the species composition of adult coprophilous insects as the substrate ages. In the literature there is some information about the succession of coprophilous insects in cattle dung (mostly Diptera and Coleoptera) from various regions of the world [Kessler & Balsbaugh, 1972; Koskela, 1972; Koskela & Hanski, 1977; Papp, 1976, 1992; Kashcheev et al., 1990; Negrobov, 1999], however, the nature and rate of successional processes are affected by the distinctive substrates from different animal species as well as regional factors. Over the past several years we have studied the fauna and the ecological peculiarities of coprophilous insects in mountainous pasturelands of southeastern and eastern Kazakhstan and Gorny Altai. One of the goals of our research was to investigate the successional changes in the community of coprophilous insects.

### Results and Discussion

Horse dung differs in consistency from the dung of cattle, sheep, and other domestic animals in its pronounced fragmentation, friable structure, and the longer time it retains a high moisture content. These microbiological peculiarities affect not only the species composition of coprophils, but also the duration of successional processes.

The results of the analysis of data obtained from traps and from direct observation of substrates have shown that the general nature of the succession of adult flies on equine dung depends little on biotope. In all cases (mountain-steppe pastures, tall grass mixed graminaceous pastures in the alpine forest zone, and patches of grassland in mixed forests) Sphaeroceridae, Anthomyiidae, Sarcophagidae were dominant on equine dung from the first moments of its existence (unlike on cattle

Table 1. Prevalence of individual families of coprophilous flies (%) on horse dung as a function of age of dung.  
Таблица 1. Доля отдельных семейств копрофильных мух (%) в помёте лошадей в зависимости от возраста помёта.

Diptera	Age of dung (hours)								
	0.16	1	3	6	12	24	36	48	72
Sepsidae	5.1	4.3	1.3	2.2	0.0	0.0	0.0	0.0	0.0
Muscidae	15.4	1.8	0.9	2.2	3.9	0.0	0.0	0.0	0.0
Sphaeroceridae	30.8	70.6	70.7	89.7	69.2	78.6	0.0	0.0	0.0
Scatophagidae	1.7	3.7	1.3	0.7	0.0	0.0	0.0	0.0	0.0
Calliphoridae	11.1	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Anthomyiidae	23.9	12.9	15.9	3.0	11.5	14.3	0.0	0.0	0.0
Sarcophagidae	11.1	6.1	9.5	1.5	15.4	7.1	0.0	0.0	0.0
Ulidiidae	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Piophilidae	0.0	0.0	0.4	0.7	0.0	0.0	0.0	0.0	0.0

dung where there was expressed dominance by Sepsidae and Muscidae). The rate of succession depends on the biotopic conditions, the most important of which are temperature and moisture. In mixed forests, where shade retards the “aging” process, the substrate will be used by flies for feeding and oviposition for a much longer time. Additionally, weather conditions, which determine the activity of flies and significantly affect the trophic properties of dung, greatly influence the course of succession. Of the nine families of Diptera found on individual piles of horse excrement, the most numerous were Sphaeroceridae (*Sphaerocerasp.*, *Leptocerasp.*, *Copromyza* spp.), Muscidae (*Pyrellia cadaverinae* (F., 1761), *Polietes* spp., *Morellia* spp. and others), Anthomyiidae (*Hylemyia* spp.), and Sarcophagidae (*Ravinia striata* (F., 1794), *Bellieria melanura* (Mg., 1826) *Sarcophaga* sp., *Parasarcophagasp.*). Species of Calliphoridae (*Lucilia* sp., *Calliphora* spp.), Sepsidae (*Sepsis* spp.), Scatophagidae (*Scathophaga stercoraria* L., 1758), Ulidiidae (*Phyziphora* sp.), and Piophilidae (*Piophla* sp.) were present in small numbers or as individual specimens. The main aggregation of flies visited horse dung for feeding, copulation, and oviposition within the first three hours after its deposition (Table 1). The most numerous visits in this period were made by *Copromyza* spp., *Leptocera* spp., *Hylemyia strigosa*, *Ravinia striata*, and *Bellieria melanura*. Significantly fewer visits were made by *Polietes* spp., *Morellia* spp., species of *Calliphora*, *Lucilia*, and *Scatophaga stercoraria*, all of which visited dung only in the first 3 hours and afterwards were not observed further. After 3–5 hours, the surface of horse dung dries and loses its attractiveness for the majority of the fly species that visited it earlier, however the number of Sphaeroceridae, Sarcophagidae, and Anthomyiidae still remains quite high even on twelve-hour-old excrement. Only *Leptocera* sp. and isolated individuals of *Hylemyia* sp. and *Ravinia striata* are observed on 24-hour old horse dung.

With inclement weather conditions (precipitation, high wind, cloud cover), the described successional change in species composition does not follow such clearly expressed nature. In the presence of high humidity and cloud cover, excrement remains suitable for as a food source for flies for a longer period, and therefore even after one or two days the number of flies can remain quite high (65.2 to 79.3 % of the initial number). At the same time, with high air temperature, intense insolation, and high wind, the number of flies on the substrate already may recede to 34.1% of the initial number after 2.5 to 3 hours. The number of flies on the substrate and duration of use sharply increase after a prolonged rainfall and the accompanying fall in temperatures, during which time the flies were deprived of the possibility to feed.

In terms of numbers, adult Hymenoptera constitute only a minor portion of the coprophilous insects on dung. Even in this group successional changes are clearly evident. The changes in species composition in this case, however, are less associated with the temporal changes in the trophic and topical properties of the dung than with the preimaginal stages of fly instars inhabiting the dung that are used by female parasitoids for the deposition of their eggs. Cynipoidea (*Figites* spp., *Eucoila* sp., *Trybliographa submontana* (Psarev, 1990), invading I–II instars fly larvae, are the first to appear on fresh dung. These parasitoids are encountered mainly on one to two-day old dung heaps. With increasing age of the substrate and development of fly larvae, Braconidae (*Phaenocarpa* spp., *Pentapleura* sp.) and Ichneumonidae (*Atractodes* spp., *Phygadeuon* spp.) parasitize the larvae of later instars. Pteromalidae (*Spalangia* spp.), whose females parasitize one to two-day old fly pupae, are encountered last of all. It should be noted that single individuals of Hymenoptera not are found on substrates for as long a time as, for example, Coleoptera, and leave the dung after a few hours. Data on the dominance of individual families of Hymenoptera at various stages of succession are shown in Table 2.

Table 2. Dominance of the most important families of parasitoid Hymenoptera on dung of various age (%).  
Таблица 2. Доминирование важнейших семейств паразитических перепончатокрылых в помёте разного возраста (%).

Age of dung (days)	Families of Hymenoptera	Dominance (%)
I	Figitidae	42.9
	Eucoliidae	57.1
II	Figitidae	42.9
	Eucoliidae	57.1
III	Figitidae	30.0
	Eucoliidae	60.0
	Braconidae	5.0
	Ichneumonidae	5.0
IV	Figitidae	18.2
	Eucoliidae	36.4
	Braconidae	18.2
	Ichneumonidae	27.4
V	Eucoliidae	8.3
	Braconidae	25.1
	Ichneumonidae	58.3
	Pteromalidae	8.3
VI	Braconidae	38.5
	Ichneumonidae	38.5
	Pteromalidae	23.0
VII	Braconidae	12.5
	Ichneumonidae	50.0
	Pteromalidae	37.5

Coleoptera outnumbers other coprophils, and it is therefore rather difficult to keep track of the qualitative and quantitative changes during succession of this group. For one thing, most of them are too small and difficult to count (Ptilidae, some *Oxytelus*, *Atheta* among the Staphylinidae). Others may form local aggregations and afterwards disperse evenly over the pasture (Aphodiinae). Thirdly, some are very mobile and may leave the substrate several times per day (*Philonthus*). Fourthly, the association with dung for some may be merely accidental, and so forth.

The greatest number of Scarabaeidae are noticed during the first day of succession, although the numbers remain high even on the second day. Among the first to appear are *Aphodius* spp. (*A. rectus* (Motsch., 1866), *A. sabulicola* (Thoms., 1868), *A. erraticus* (L., 1758) and others), *Onthophagus* spp. (*O. gibbulus* (Pall., 1781), *O. fracticornis* (Prey., 1790), *O. laticornis* (Gebl., 1823), *O. marginalis* (Gebl., 1817), *O. nuchicornis* (L., 1758)), *Geotrupes baicalicus* (Rtt., 1893). By the second day the species composition is completely formed. The most common species for this substrate, besides the above

mentioned, are *Aphodius immundus* (Cr., 1799), *A. vittatus* (Say, 1825), *A. fossor* (L., 1758), *A. carinatus* (Germ., 1824), *A. pusillus* (Hbst., 1789), and others. It should be noted that during the colonization of horse dung Aphodiinae are not as prominent in the population as they are in cow dung. Moreover, it is noticed that Scarabaeinae and Geotrupinae sometimes dominate.

The majority of species of Scarabaeidae remain on the dung for 4–5 days, however their numbers start to decrease by the third day. In 6- to 7-day old dung one can observe *Aphodius foetens* (F., 1787), *A. fimetarius* (L., 1758), and *A. rectus*, *A. immundus* is rarer. According to their time of contact with the substrate, it is possible to group species of Scarabaeidae into those that are encountered during the first 2–2.5 days (*Onthophagus* spp., *Geotrupes baicalicus*, *Aphodius fossor*, *A. depressus* (Kug., 1798), *A. erraticus*); those encountered during 4–5 days (almost all *Aphodius* — *A. rectus*, *A. immundus*, *A. ater* (Deg., 1774), *A. haemorrhoidalis* (L., 1758) and others), and those present until almost total desiccation (*A. fimetarius*, *A. subterraneus* (L., 1758)). During the colonization of the substrate we noticed that a number of species has a tendency to aggregate, observing during the first twenty-four hours *A. erraticus*, *A. haemorrhoidalis*, *Onthophagus nuchicornis* and others beetles that are concentrated into separate loci consisting of groups of 8 to 15. Mating occurs during this time, some beetles fly away, the distribution of *Aphodius* becomes relatively even, *Onthophagus* is dispersed below the dung.

Characteristic for Hydrophilidae on horse dung is a greater variety of species of *Cercyon* (*C. melanocephalus* (L., 1758), *C. unipunctatus* (L., 1758), *C. quisquilius* (L., 1761), and others). The highest numbers of *Sphaeridium* spp. (*S. scarabaeoides* (L., 1758), *S. bipustulatum* (F., 1781), *S. lunatum* (F., 1792)) are noticed between 1.5 to 2 days. By the end of the first to the beginning of the second day an intensive flight of small Hydrophilidae (*Pachysternum* sp., *Cryptopleurum* sp., *Cercyon* spp.), whose numbers remain high until about the 4<sup>th</sup> to 5<sup>th</sup> day, after which the numbers gradually decrease. Not many species of *Cercyon* are encountered on old dung of eight to days of age.

Histeridae are present on horse dung from the first hours of its existence almost until its total desiccation. However their numbers are less than that of other Coleoptera. *Hister* (*H. sibiricus* (Mars., 1858), *H. bipustulatus* (Schränk, 1781) et al.), *Margarinotus* (*M. cadaverinus* (Hoff., 1803), *M. ventralis* (Mars., 1854)), *Saprinus* (*S. spernax* (Mars., 1862)), *Atholus* (*A. bimaculatus* (L., 1758), *A. duodecimstriatus* (Schränk, 1781)) are the most usually encountered species, whose population peaks between 2.5–3 days, at the time when the eggs and larvae of coprophilic insects are most abundant.

Successional processes proceed more complicatedly in the large group of coprophilic Staphylinidae than in other beetles. Their qualitative and quantitative presence in excrement of various ages is determined by specific trophic species, among which are coprophagous, predatory, saprophagous, and mycetophagous

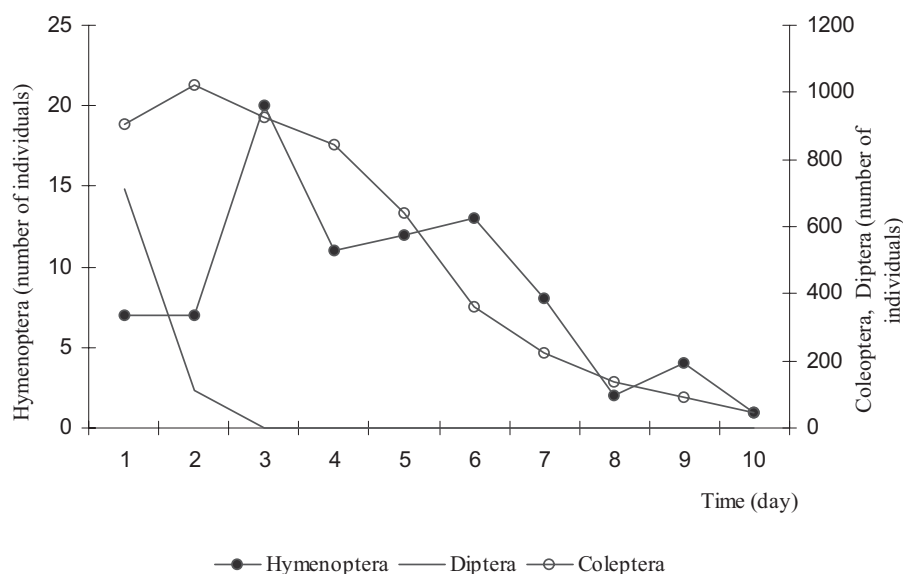


Fig.1. General dynamics of number of imagoes of coprophilous insects on horse dung dependent on age of dung.

Рис.1. Общий ход динамики численности имаго копрофильных насекомых на конском помете в зависимости от его возраста.

species. The species composition of staphylinids unfolds by the second day, but peak density is not seen until the fifth day (up to 120 specimens/dm<sup>3</sup>), chiefly small coprophagous and mycetophagous species. During the first hour appear coprophages (*Platystethus cornutus* (Grav., 1802), *P. arenarius* (Four., 1785), *Oxytelus piceus* (L., 1767) and others) as well as predators (*Ontholestes murinus* (L., 1785), *O. tessellatus* (Four., 1785), some *Philonthus* — *Ph. agilis* (Grav., 1806), *Ph. cruentatus* (Gmel., 1790), *Ph. marginatus* (Stroem, 1768) and others). As the dung dries out, the number of predators increases. This is a time of intensive predatory activity on adult flies by *Ontholestes* (for medium sized flies) and *Philonthus* (on larger flies). After 2–2.5 days *Ontholestes* leaves the substrate, but *Philonthus* spp. switches to feeding on mostly larvae of other coprophils. In general, the numbers of the majority of predatory species gradually increase until the 3–4 day, after which their numbers decrease. On the 5–7 day remain mainly medium to large species (*Philonthus cruentatus*, *Ph. sanquinolentus* (Grav., 1802), *Ph. rectangulus* (Sharp, 1874), *Ph. splendens* (F., 1792), *Ph. nitidus* (F., 1787), more rarely *Emus hirtus* (L., 1758) and others) in the dung, because by this time the fly larvae have reached an advanced stage and are no longer accessible for the small predators. Around 3–4 days are found the maximum number of *Aleochara* spp. (*A. bipustulata* (L., 1761), *A. intricata* (Mnsh., 1830), *A. milleri* (Kr., 1862)), whose larvae occur ectoparasitically on fly pupae.

The general course of the dynamics of adult insects connected to horse dung is shown in Fig. 1 (not including the small *Atheta* (Staphylinidae), *Acrotichis* (Ptiliidae) and accidental species). Comparing the succession in

horse dung with that in cow dung, one can notice some differences in the species composition of insects and in the rate of changes. The dynamics of the numbers of individual species is determined by physical peculiarities of the substrate and chronology. In contrast to cow dung, where Sepsidae and Muscidae dominate from the first hours of its existence, on horse dung Sphaeroceridae, Anthomyiidae, Sarcophagidae are the dominant groups. Horse dung, due to its substrate peculiarities, is utilized for a longer time by flies for feeding than is cow dung, and is characterized by a greater compactness and higher density of Coleoptera at all stages of succession.

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