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Assemblages of Coprophilous Beetles (Insecta: Coleoptera) in the Pastureland of Central Mongolia

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Abstract

Results of studies on species composition, abundance and community structure of beetles found in dung of the reintroduced wild horses (Przewalski's horses), domestic horses and cattle are presented. Beetles were collected using pitfall traps baited with fresh dung as an odor attractant. Four species of dung beetles, *Aphodius erraticus* (Linnaeus, 1758), *A. subterraneus* (Linnaeus, 1758), *Gymnopleurus mopsus* (Pallas, 1781), *Onthophagus gibbulus* (Pallas, 1781), one species of rove beetle, *Staphylinus dauricus* Mannerheim, 1830, and another species of burying beetle, *Nicrophorus argutor* Jakovlev, 1890 are found. In most dung, the lamellicorn beetle species, namely *O. gibbulus*, *A. erraticus* and *G. mopsus* are dominated, which composed up to 80% of all entrapped beetles. The two species of rove and carrion beetles, *S. dauricus* and *N. argutor* were less numerous in traps, although the first species abundantly occurs in exposed horse dung. Study sites with little or no grazing differ from intensively grazed pastures not only by higher diversity of coprophilous beetles, but also in the greater number of dominating species, as well as their abundance. Significant negative correlations were found among the species richness, abundance of coprophilous beetles and number of herbivore droppings.

Key words: coprophilous beetles, community structure, dung, Scarabaeidae, Staphylinidae, Silphidae, pasture, Mongolia

Introduction

The dung of herbivorous animals represents patchy and ephemeral habitats for some arthropods, mollusks, worms etc. Physical, chemical and biotic conditions in the droppings change relatively slowly and it is more stable inside than the ground surface environment in terms of thermal and moisture factors.

Because of high contents of nutritional components, herbivore droppings constitute attractive habitat for many groups of arthropods, including insects, spiders, pseudoscorpions, centipedes, millipedes, mites, some mollusks, and worms (earth worm, round worm, pot worm etc.), as well as their larvae and nymphs (Makarova, 1992; Pérez-Bañón *et al*., 2003; Horesntein *et al*., 2007).

The characteristic pattern of the coprophilous insect communities in temperate regions is dominance of dung beetle species (Scarabaeidae), especially small- to medium-sized members belonging to the genera *Aphodius* and *Onthophagus*. Almost all dung beetles are coprophagous, however some of them are found to be saprophagous, e.g. numerous species of the subfamily Aphodiinae (Hanski, 1980; Hanski & Cambefort, 1991; Liybechanskii & Smelyanskii, 1999).

Beetles belonging to the family Staphylinidae are mostly predators, but it encompasses many saprophagous and coprophagous species, hence they occur in a wide range of habitats including herbivore droppings, manure, animal nests etc. In the meantime, the carrion beetles have a complex position in the food web as they are necrophagous, and are most common on carrion, but some occur in decomposing vegetation and animal droppings. Adult carrion beetles are largely predaceous on developing fly larvae in the dropping prior to burying the carrion (Cambefort & Hanski, 1991; Zunino *et al*., 1994).

Adults of some species of these beetle groups use dung as a breeding site, and they lay their eggs in the fresh droppings of herbivores to provide food and habitat for the larvae, which inhabit there during its complete developmental period. Both adults and larvae play important roles in

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decomposition of exposed excrements, and they habitually dig tunnels in the soil under dung pads and carry the dung fragments to the bottom for consumption. This habit increases soil fertility and porosity, and they play a significant role in reducing populations of parasitic organisms living in various type of dung. Thus, they are responsible for the large part of dung decomposition and take part in the maintenance of soil fertility (Striganova, 1967; Nilssen *et al*., 1999; Psarev, 2001; Floate, 2006).

Species composition of lamellicorn, rove and carrion beetles in Mongolia is well known upon the bases of taxonomic and faunistic investigations, and some information on their dispersal and habitat ecology are available (e.g. Emetz, 1975; Medvedev, 1976; Nikolaev & Puntsagdulam, 1984; Otto & Peter, 1988; Ulykpan, 1988). On the other hand, completely lacking is the data on communities of coprophilous insects in Mongolia. Moreover, natural degradation of herbivore dung and contribution of arthropods in this process are almost completely unknown in case of Mongolia although the country has extensive, traditional nomadic animal husbandry. Answers to essential questions concerning destruction rate of herbivore dung under various conditions of Mongolia, and the importance of coprophagous arthropods and other organisms in this process are still lacking.

The main aim of the present study is to determine the species composition and community structure of beetles inhabiting wild and domestic horses, as well as cow dung in the mountain-steppe pastures of the Hustai National Park in Central Mongolia.

Material and Methods

The field study was carried out at the mountain-steppe pastures with different grazing regimes in the Hustai National Park, Central Mongolia in July and August 2009. As Mongolia has an extensive, traditional nomadic animal husbandry, the land area of this national park temporarily used for grazing by livestock of local herders with additional grazing of wild herbivores such as Przewalski's horse, red deer, white tailed gazelle etc. An area like the Hustai National Park, where significant numbers of both wild and domestic herbivores are still existent, can be an ideal subject for studying dung beetles and their links other mammalian species.

The vegetation in the study area lies within the mountain steppe levels (1260-1420 m a.s.l.), and covered with steppe vegetation dominated by several grass species, a variety of herbs and legume dwarf-shrubs as *Elymus chinensis*, *Stipa krilovii*, *Artemisia adamsii*, *Convolvulus Ammanii*, *Kochia prostrata* etc. The vegetation and land cover type patterns of the Hustai National Park are reflected in the work by Wallis de Vries *et al*. (1996) and Bayarsaikhan *et al*. (2009).

In total, four different study sites were chosen, which exhibit similar landscape pattern and vegetation cover (Fig. 1A-D). Total number of exposed droppings of large herbivores (wild and domestic horses, cows) in each study site was counted to estimate the grazing intensity of each pasture.

Beetles were collected using pitfall traps baited with fresh dung (as an odor attractant) of wild and domestic horses, as well as cows. We adopted pitfall traps made of plastic buckets, buried up to its upper margin in soil, covered with a metallic net (Fig. 1G & H).

In one study site we chose three plots each with 10 x 10 m area. In one plot, 9 traps were placed in quadrangular configuration, with 3.3 m between each trap, and were examined twice a day (at 9 AM and 9 PM; Fig. 1E). While still alive, the total number of arrived beetles in the samples was hand sorted under a dissecting microscope.

The dominance coefficient was calculated as the number of specimens of particular beetle species to the total number of all analyzed beetles, and expressed as a percentage. The following dominance classes were distinguished: superdominants (>10.0%), dominants (5.1-10.0%), subdominants (2.1-5.0%), residents (1.1-2.0%) and sub-residents (<1.0%).

Species diversity was estimated using the Shannon-Wiener's (*H'*) index.

Results

A total of 495 adult beetles belonging to six species of four genera and three families were collected in the dung-baited traps. The beetle communities in all study sites were dominated by *Onthophagus gibbulus* (Pallas, 1781), *Aphodius erraticus* (Linnaeus, 1758) and *Gymnopleurus mopsus* (Pallas, 1781), which constitute 62 to 80% of all beetle specimens collected. Another dung beetle species, *A. subterraneus* (Linnaeus, 1758) is made up 12-18% of all caught beetles in the traps

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Figure 1. Main types of mountain-steppe habitats, collecting techniques of coprophilous beetles and examples of exposed dung in the pastures. A – Pasture grazed by cattle; B – Pasture grazed by sheep and goats; C – Pasture grazed by domestic horses; D – Pasture grazed by wild horses; E – Counting of coprophilous beetles in the field; F – A fresh cow dung in the pasture; G – A pitfall trap baited with dung; H – Entrapped beetles; I – A fresh horse pile in the pasture.

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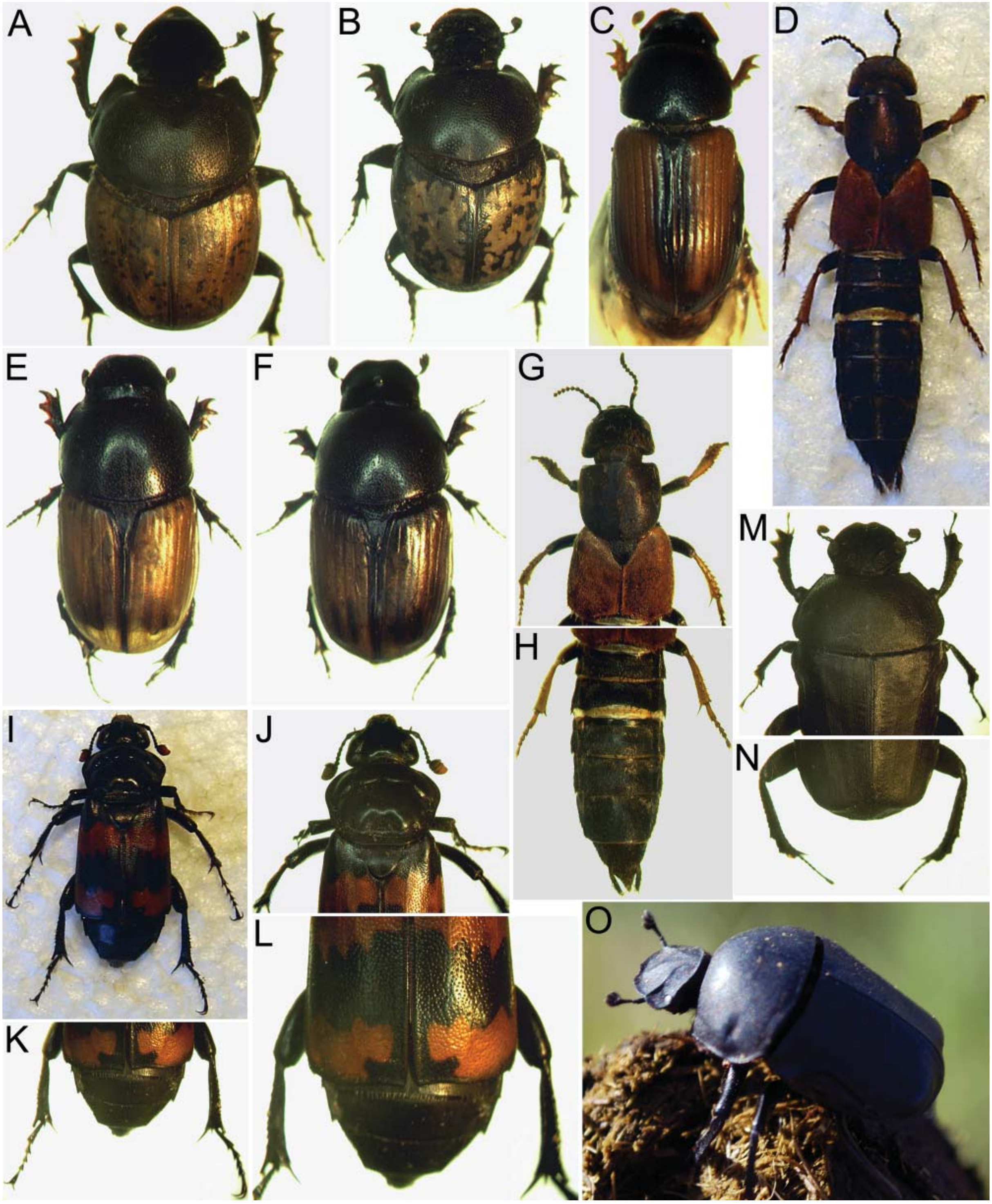

Figure 2. Coprophilous beetles recovered from the dung-baited traps in pastures of the Hustai National Park. A – *Onthophagus gibbulus*, male, dorsal view of idiosoma; B – *O. gibbulus*, female, dorsal view of idiosoma; C – *Aphodius subterraneus*, dorsal view of idiosoma; D – *Staphylinus dauricus*, dorsal view of idiosoma; E – *Aphodius erraticus*, female, dorsal view of idiosoma; F – *A. erraticus*, male, dorsal view of idiosoma; G – *Staphylinus dauricus*, anterior part of idiosoma; H – *S. dauricus*, posterior part of idiosoma; I – *Nicrophorus argutor*, dorsal view of idiosoma; J – *N. argutor*, anterior part of idiosoma; K – *N. argutor*, posterior part of abdomen and hind legs; L – *N. argutor*, posterior part of idiosoma; M – *Gymnopleurus mopsus*, anterior part of idiosoma; N – *G. mopsus*, posterior part of idiosoma; O – *G. mopsus*, dorso-lateral view of idiosoma.

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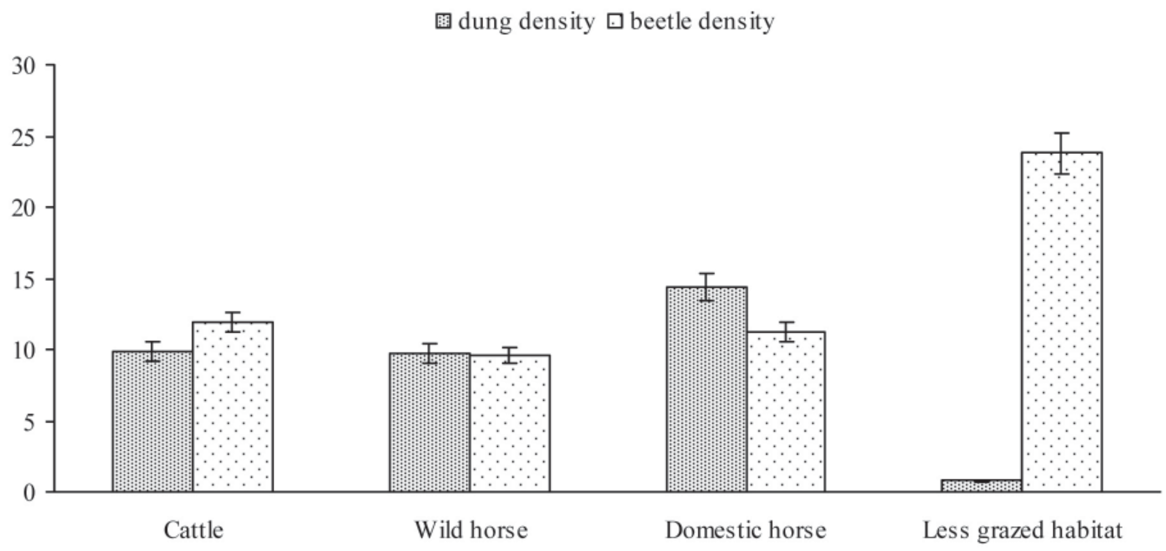

Figure 3. Average density of the entrapped coprophilous beetles (individual per trap) and dung in pastures (droppings per 10 x 10 m area) with different grazing patterns.

placed in less grazed pastures. Less numerous beetles were *Staphylinus dauricus* Mannerheim, 1830 and *Nicrophorus argutor* Jakovlev, 1890, which were accidentally entrapped in some pastures (Fig. 2).

The wild horse pasture contains four species of dung beetles with highest abundance of *O. gibbulus* and *A. erraticus*. A relatively less diversity of beetles occurred in the pastureland of domestic horses and cattle, where only three beetle species were recorded in each. Dominating species of beetles in the domestic horse pasture were same as those of the wild horses, but the cattle dung-baited traps contained only a single dominant species, *A. erraticus*.

Pasturelands with less or no grazing show the highest diversity of dung beetles with additions of the members of two other families, *S. dauricus* (Staphylinidae) and *N. argutor* (Silphidae), which were trapped by chance.

The number of beetles caught in traps varied considerably (from 0 to 58) during the day and night time, as well as among different traps within a same study site. In addition, abundances of beetles in different animal dung-baited traps are considerably variable. Thus the average number of beetles attracted to the wild horse dung is fluctuated between 6 and 13 individuals per trap, while that of the domestic horses is more variable, namely from 3 to 24. The abundance of beetles in the cow dung-baited traps shows a similar pattern of fluctuation to that of domestic horses, with average number of 2 to 22 individuals per trap.

The greatest abundance of coprophilous

Table 1. Community structure of the coprophilous beetles in pastures with different grazing

Community structure parameters	Herbivore species			Less or non-grazed pasture
	Przewalski's horse	Domestic horse	Cow	
Species richness	4	3	2	6
Species diversity, *H'*	2.8	2.5	2.1	3.1
Mean abundance per trap	9.6	11.2	11.9	23.8
Occurred beetle species	*O. gibbulus* *A. erraticus* *A. subterraneus* *S. dauricus*	*O. gibbulus* *A. erraticus* *S. dauricus*	*O. gibbulus* *A. erraticus* *G. mopsus*	*O. gibbulus* *A. erraticus* *A. subterraneus* *S. dauricus* *G. mopsus* *N. argutor*
Dominating species with >10% dominance	*O. gibbulus* *A. erraticus*	*O. gibbulus* *A. erraticus*	*A. erraticus*	*A. subterraneus* *G. mopsus* *O. gibbulus*

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beetles was recorded during the night time in traps baited with cow and domestic horse dung, where 58 and 57 individuals were caught in one trap, respectively though the number of beetles was not even in each sample. In the meantime, the absolute abundance of beetles in the traps with wild horse dung was 37 with relatively high evenness of the species occurrence in most traps. Study sites with less or no grazing differ from other sites not only by higher diversity of beetles, but also in the greater number of dominating species as well as their abundance.

Density of herbivore droppings is also varied significantly. Thus, the number of cattle dung in 100 m^2 area is fluctuated between 2 to 18, that of wild horse dung was 2 to 22, domestic horse dung – 3 to 28, and dung in the less or non grazed pasture – 0 to 3. An average of densities of the entrapped coprophilous beetles and dung in pastures with different grazing is shown in Fig. 3.

Species diversity of the captured beetles in the less or non-grazed habitats show the highest value due to a greater number of species, more evenness of the individuals of different taxa and relatively larger number of dominating species. The value of *H'* was comparatively higher in the wild horse pasture than that of the domestic horse pasture. With less number of inhabiting species and single dominating taxon, the diversity index value of the beetles in the cattle dung was significantly lower than those in other pastures (Table 1).

We expected to find the highest diversity and greatest abundance of coprophilous beetles in the heavily grazed areas where a large number of herbivore droppings are counted. This prediction was based upon the availability of sufficient provision of the herbivore droppings in the intensively grazed pastures, which serve as favorable habitats for coprophilous beetles.

However, the results of the present study did not meet the above expectation, but in contrary, more diverse and abundant communities of beetles tend to occur in the less or non-grazed sites. As evaluated grazing intensity of each pasture using

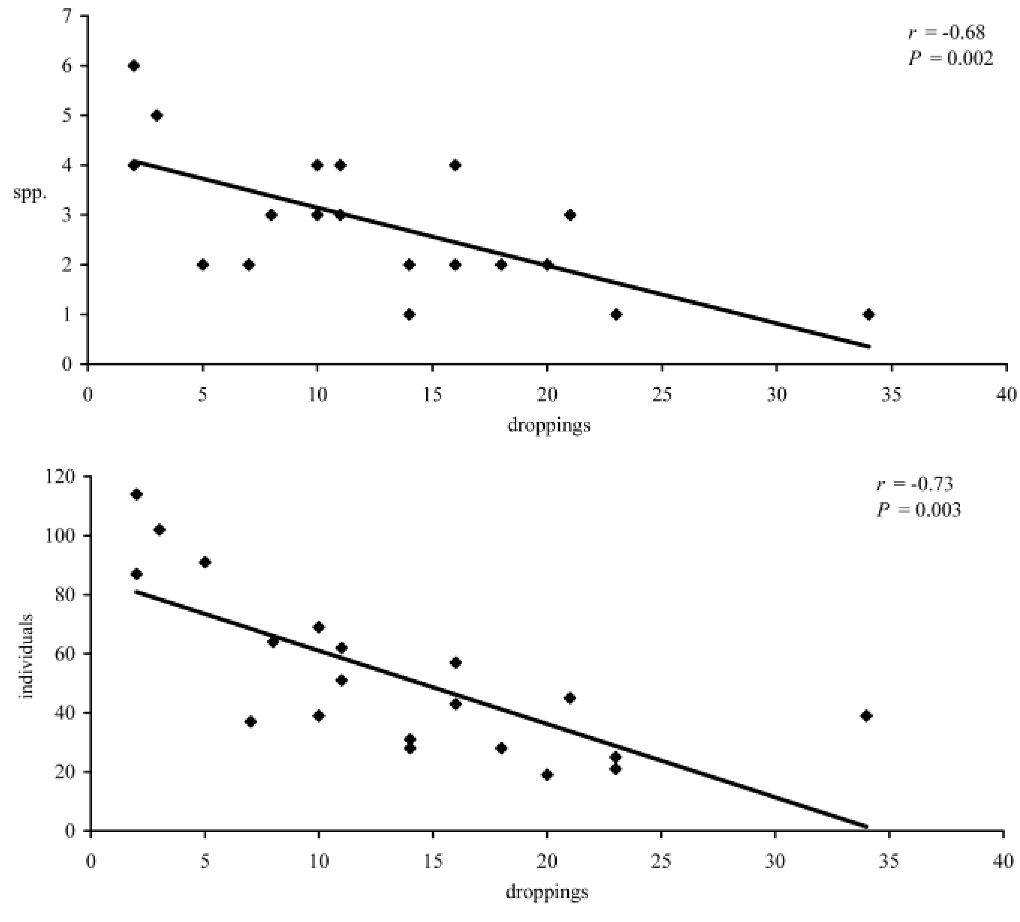

Figure 4. Correlation between species richness, abundance (total number of individuals per one plot) of coprophilous beetles and grazing intensity of pastures (droppings per 10 x 10 m area).

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number of exposed droppings of herbivores, the more heavily grazed pastures seem to support the considerably lower diversity of coprophilous beetles with relatively little abundances. A comparison of the beetle communities entrapped from the heavily grazed pastures with those of the less or non-grazed habitats indicate higher diversity with greater abundance of coprophilous beetles in the latter habitats.

Significantly negative correlations were found in the relationships between species richness, abundance of coprophilous beetles and number of herbivore droppings (Fig. 4).

Thus, both the species richness and average abundance of beetles are reduced with an increase of the density of animal droppings in the pastures, but less grazed habitats by herbivores show comparatively higher diversity of inhabitants of the dung. A similar pattern of the coprophagous beetle assemblages were revealed not only in the temperate regions, but also in the tropics (Krell & Linsenmair, 1998; Rozlin & Koivunen, 2001).

Discussion

Coprophilous beetles, especially dung-feeding beetles are among the most prominent insects in cattle and horse dung, in terms of their body size, diversity, abundance, and role in dung degradation. Assessing their influences to the decomposition of fecal residues requires information on species composition, geographic distribution and seasonal activity. Most such information for Mongolia is incomplete, and only the data on species composition and geographical ranges of species are available.

Concerning the biogeography of the coprophilous beetles found in pasturelands of the Hustai National Park, the dung beetle species, *A. erraticus*, *A. subtrerraneus*, *G. mopsus* and *O. gibbulus* have very broad distributions in the Transpalaearctic region. While two other species, *N. argutor* and *S. dauricus* show restricted distributions, which have been reported mostly from the Central Asian part of Russia, Mongolia, China and Kazakhstan.

Differences in coprophilous beetle assemblages, even over relatively short distances, can observe in different dung-baited pitfall traps. Most diverse and abundant beetles were found in the study sites with no or low grazing intensity. The pasture of wild horses contains relatively higher diversity of coprophilous beetle association than those in the cattle and domestic horse pastures.

The dung beetles, *O. gibbulus*, *A. erraticus* and *G. mopsus* are most commonly found in the horse and cattle dung-baited traps throughout the most pastures. Similar pattern of the dominance of dung beetles of the subfamily Aphodiinae was also observed in the pastures of alpine, mountain and valley pastures of northern hemisphere (Barbero *et al*., 1994; Lumaret & Stiernet, 1991; Roslin & Koivunen, 2001).

At high densities, adult activity disrupts and aerates the dung pat. On pastures in Hustai National Park, an average of 3 to 24 individuals of adult beetles has been reported to colonize fresh dung placed in one trap. It is evident that in the pastures the adults of these beetles arrive at the fresh dung pat, and tunnel within it to form brood chambers in which to lay eggs. More typically, dung degradation is associated with the feeding activity of larvae, which may consume 50% to 100% of their body weight per day (Holter, 1974). Larval feeding occurs for weeks or months, which complemented by the activities of other decomposers (fungi, bacteria etc.) to convert the pat into a dry, granular structure (Wratten & Forbes, 1996). Thus, tunneling and feeding by coprophilous insects accelerate dung degradation, which allows its pats to be more easily penetrated by vegetation and incorporated into the soil.

The beetle assemblages entrapped in the pastures with intensive grazing did not confirm our expectation that an abundant presence of herbivore droppings should determine an equally rich coprophilous fauna. Patterns of the occurrence of high diversity of coprophilous beetles in the dung-baited traps of the less extensively grazed pastures might be explained as the lack of sufficient droppings, and the demonstration of competition between the species for their browsing, sheltering or breeding microhabitats as related species utilize similar ecological resources. In contrast, the low diversity of entrapped beetles in the heavily grazed pastures would be hypothesized that the availability of sufficient number of droppings could influence the behavior of beetles that could be able to choose fresh dung with less competition.

All three kinds of herbivore dung were occupied by at least three beetle species, and those taxa are quite euryecious, but a few clear preferences were highlighted, such as that of *A. subterraneus* for wild

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horse dung. The present results have shown that *S. dauricus* and *N. argutor* are typical coprophilous species in Central Mongolia, although they also inhabit other microhabitats. Especially the latter species regularly occur on carrion, but it also appears in the dung.

The analysis of communities of other beetle groups, such as predacious, saprophagous, necrophagous, phytophagous etc. would be important to confirm this observation. Moreover, a study on community structure of coprophilous beetles in other environments would be necessary to get more information on species specific to various habitats.

In future, the development of conservation strategies for maintaining coprophilous beetle diversity as well as an indicator system for rapid evaluation and assessment of biodiversity, and for estimating the degree of its endangerment are required.

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Хураангуй

Энэхүү өгүүлэлд тахь, адуу, үхэр зэрэг өвсөн тэжээлт амьтдын бэлчээр нутагт, тэдгээрийн ялгадсанд орогнож амьдардаг копрофиль цохын бүрэлдэхүүн, элбэгшил, бүлгэмдлийн судалгааны үр дүнг тусгав. Судалгаагаар илтсэн сахалт цохын *Aphodius erraticus* (Linnaeus, 1758), *A. subterraneus* (Linnaeus, 1758), *Gymnopleurus mopsus* (Pallas, 1781), *Onthophagus gibbulus* (Pallas, 1781) зэрэг 4 зүйл, *Staphylinus dauricus* Mannerheim, 1830 зүйлийн богино далавчит цох, *Nicrophorus argutor* Jakovlev, 1890 зүйлийн сэгч цохыг илрүүллээ. Ихэнх дээжинд *O. gibbulus*, *A. erraticus* and *G. mopsus* зүйлүүд зонхилж, баригдсан нийт цохын 80 хүртэл хувийг бүрдүүлж байв. Харин *S. dauricus*, *N. argutor* зэрэг зүйл адууны хомоолд олноор орогнодог боловч амьд баригчид маш цөөн тоогоор тэмдэглэгдсэн болно. Мал бэлчээрлэдэггүй, бага бэлчээрлэдэг нутагт харьцангүй олон зүйлийн, нягтшил өндөртэй, зонхилогч зүйл олонтой цохын бүлгэмдэл илэрсэн бол мал амьтны бэлчээрлэлт ихтэй газарт копрофиль цохын бүлгэмдэл дээрхээс эсрэг үзүүлэлттэй байв. Копрофиль цохын олон янз байдал, элбэгшлийн үзүүлэлт болон тухайн бэлчээрт тохиолдох өвсөн тэжээлт амьтдын ялгадасны тооны үзүүлэлтийн хооронд сөрөг хамааралтай болохыг тогтоов.

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