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# ANALYSIS OF REGIONAL PECULIARITIES OF STRONGYLID (NEMATODA, STRONGYLIDAE) BIODIVERSITY IN DOMESTIC HORSES IN UKRAINE

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**Analysis of Regional Peculiarities of Strongylid (Nematoda, Strongylidae) Biodiversity in Domestic Horses in Ukraine. Kuzmina T. A. —** Analysis of regional peculiarities of species composition and structure of strongylid communities in domestic horses from various parts of Ukraine is presented. More than 86,000 strongylid specimens were collected using the diagnostic deworming technique from 180 horses in 10 regions (Kyivska, Kyrovogradska, Poltavska, Kharkivska, Sumska, Donetska, Ternopilska, Zakarpatska, Khersonska and AR Crimea) and identified to the species level. Thirty-three strongylid species from 12 genera were found — 26 species in the subfamily Cyathostominae and seven — in the subfamily Strongylinae. General structure of the strongylid community appeared to be multimodal. The highest biodiversity of strongylids was found in horses from Southern regions of Ukraine (29 species from 12 genera) and the lowest in Eastern regions (15 species from six genera). However, no statistically significant differences in species composition of strongylid communities in horses from various regions of Ukraine were found ($p > 0.05$). Comparison of strongylid biodiversity in domestic horses from Ukraine with that from others countries revealed the highest similarity of the strongylid communities from Ukraine, Czech Republic, and Poland; the lowest was in horses from South Africa and north-western Europe (France and the UK). Our results showed that the peculiarities of horse-keeping conditions influenced the biodiversity of the strongylid communities in domestic horses much more than climatic conditions in various regions.

Key words: strongylida, Cyathostominae, strongylid community, domestic horses, Ukraine.

**Анализ региональных особенностей видового разнообразия стронгилид (Nematoda, Strongylidae) домашних лошадей Украины. Кузьмина Т. А. —** Проведен анализ региональных особенностей видового разнообразия и структуры сообществ стронгилид домашних лошадей из разных регионов Украины. Методом диагностической дегельминтизации собрано и определено до вида более 86 тысяч экз. стронгилид от 180 домашних лошадей из 10 областей (Киевской, Кировоградской, Полтавской, Харьковской, Сумской, Донецкой, Тернопольской, Закарпатской, Херсонской областей и АР Крым). Зарегистрировано 33 вида стронгилид из 12 родов — 26 видов циатостомин и 7 видов стронгилин. Обнаружена мультимодальная структура сообщества стронгилид. Наибольшее видовое разнообразие сообщества стронгилид обнаружено у лошадей из южных областей Украины (29 видов из 12 родов), наименьшее — в восточных областях (15 видов из 6 родов). Однако статистически достоверных различий в видовом разнообразии сообществ стронгилид лошадей из разных областей Украины не обнаружено ($p > 0{,}05$). При сравнении видового разнообразия сообществ стронгилид домашних лошадей Украины с таковыми из других стран мира обнаружено наибольшее сходство сообществ у лошадей Украины, Чехии и Польши. Наибольшие достоверные отличия в видовом составе сообществ обнаружены у лошадей Южной Африки, а также северо-западной Европы (Франция и Великобритания). Результаты нашей работы показывают, что особенности условий содержания домашних лошадей оказывают более сильное влияние на видовое разнообразие сообществ стронгилид, чем разница климатических условий региона.

Ключевые слова: стронгилиды, Cyathostominae, структура сообщества, домашние лошади, Украина.

**Introduction**

Species of the family Strongylidae (Nematoda: Strongylida) parasitize domestic and wild horses (Equidae) worldwide (Lichtenfels, 1975; Dvojnos, Kharchenko, 1994; Lichtenfels et al., 2008). A number of horse strongylids has been described to date: 64 species in two subfamilies, Strongylinae (13 species) and Cyathostominae (51 species) (Lichtenfels et al., 2008). However, the "core" of the strongylid community in domestic horses is comprised mainly of 10–12 of the most prevalent species that represent more than 90% of strongylid communities (Ogbourne, 1976; Reinemeyer et al., 1984; Dvojnos and Kharchenko, 1994; Gawor, 1995; Lyons et al., 1996; Silva et al., 1999; Kaplan, 2002; Kuzmina et al., 2005).

During the past few decades, there has been an increase in interest to investigate the species composition of horse strongylid communities in many countries of Europe (Gawor, 1995, 2006; Collobert-Laugier et al., 2002; Osterman Lind et al., 2003; Traversa et al., 2007; Kornas et al., 2010; Kuzmina et al., 2005, 2011), North and South America (Anjos, Rodrigues, 2003; Silva et al., 1999; Tolliver, 2000; Chapman et al., 2002; Lyons et al., 1994, 1996) and Australia (Mfitilodze and Hutchinson, 1985; Bucknell et al., 1995, 1996). It was found that, despite a dominance of a dozen of the most prevalent species in strongylid communities worldwide, biodiversity of communities in domestic horses differ in various countries. These differences may be caused by peculiarities of climate as well as a difference in horse management systems in various countries.

During the last decade, we have studied the strongylid communities in domestic horses from various regions of Ukraine (Kuzmina et al., 2005, 2009). Species composition and structure of strongylid communities were analyzed in various types of horse breeds and under different horse-keeping conditions. However, no analysis of strongylid community structure in relation to regional natural and climatic conditions has been performed yet.

Ukraine is situated in a moderate climatic zone. Despite its rather large dimensions (from 52°20′ to 44°20′ N and from 22°5′ to 41°15′ E), Ukraine has very little diversity in climatic conditions. There are three main natural zones in Ukraine — the forest zone (Polissia) in the northern part, the forest-steppe zone in the central part, and steppe zone in the southern part of the country. The horse-breeding industry is developed mainly in the western, central, and eastern parts of Ukraine. Currently, there are more than 500,000 horses in nine breeds that are kept on various types of Ukrainian horse farms (Kuzmina et al., 2008).

The aim of the current study was to analyze the regional peculiarities of species composition and structure of strongylid communities in horses from various parts of Ukraine. Special attention was given to comparison of strongylid communities' biodiversity in domestic horses from Ukraine and from other parts of the world.

**Material and methods**

Our study was carried out on 180 domestic horses from horse farms from 10 administrative regions (oblasts) of Ukraine — Kyivska (30 horses), Kyrovogradska (39), Poltavska (22), Kharkivska (12), Sumska (14), Donetska (8), Ternopilska (12), Zakarpatska (11), Khersonska (18), and AR Crimea (14) (fig. 1).

All horses were kept under stable-pasture or stable-paddock horse-keeping conditions and were infected naturally with strongylids. The level of infection was analyzed by the coprological McMaster method with a sensitivity of 25 eggs per gram of faeces (EPG) (Herd, 1992). All horses selected had levels of infection not less than 200 EPG and had not been dewormed with any anthelmintics during at least three months prior to our studies.


Fig. 1. Regions of studies and number of animals studied.

Рис. 1. Регионы исследований и количество исследованных животных.

The *in vivo* method of diagnostic deworming (Kuzmina et al., 2004) was used to collect strongylids. In total, 86,036 strongylid specimens were collected and identified under light microscope by morphological criteria (Dvojnos, Kharchenko, 1994; Lichtenfels et al., 2008).

The distribution of strongylid species among 10 prevalence classes (0–10 %, 11–20 %, ... 91–100 %) was performed according to Bucknell et al. (1995).

The Paleontological Statistics Software (PAST) (Hammer et al., 2001) was used for statistical analysis of the results obtained. Nonparametric Mann—Whitney test (U) was used to compare species composition of strongylid communities in horses from various regions of Ukraine and other countries. Bray–Curtis cluster analysis was performed using the Biodiversity Professional v. 2.04.

## Results

### *General characteristic of strongylid community in Ukrainian horses*

Thirty-three strongylid species from 12 genera were found in domestic horses from 10 regions of Ukraine: 26 species of cyathostomes (subfamily Cyathostominae) and seven — of strongylines (subfamily Strongylinae) (fig. 2). From 5 to 23 species (10.38 ± 3.8 SD) were observed in an individual horse.

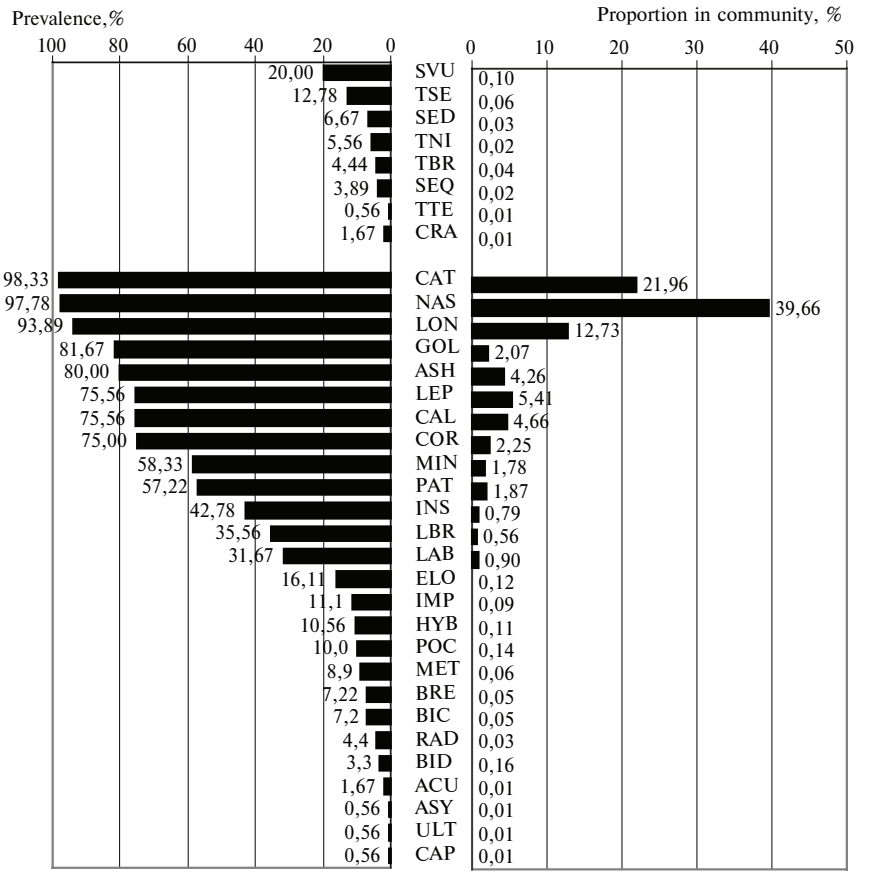


Fig. 2. Prevalence of infection (%) of separate strongylid species and their proportion in the strongylid community: Strongylinae: SVU — *Strongylus vulgaris*; SED — *S. edentatus*; SEQ — *S. equinus*; TSE — *Triodontophorus serratus*; TNI — *T. nipponicus*; TBR — *T. brevicauda*; TTE — *T. tenuicollis*; CRA — *Craterostomum acuticaudatum*; Cyathostominae: CAT — *Cyathostomum catinatum*; PAT — *C. pateratum*; COR — *Coronocyclus coronatus*; LBR — *C. labratus*; LAB — *C. labiatus*; NAS — *Cylicocyclus nassatus*; ASH — *C. ashworthi*; LEP — *C. leptostomus*; INS — *C. insigne*; ELO — *C. elongatus*; BRE — *C. brevicapsulatus*; RAD — *C. radiatus*; ULT — *C. ultrajectinus*; LON — *Cylicostephanus longibursatus*; GOL — *C. goldi*; CAL — *C. calicatus*; MIN — *C. minutus*; HYB — *C. hybridus*; BID — *C. bidentatus*; ASY — *C. asymetricus*; IMP — *Poteriostomum imparidentatum*; POC — *Petrovinema poculatum*; MET — *Parapoteriostomum mettami*; BIC — *Cylicodontophorus bicoronatus*; CAP — *Gyalocephalus capitatus.*

Рис. 2. Экстенсивность инвазии (%) и доля разных видов стронгилид в сообществе.

Cyathostomes were dominant in the strongylid community; they were observed in 100 % of the horses examined and constituted 99.73 % of the strongylid number. Strongylines were found in 32.2 % of horses and constituted 0.27 % of the strongylids.

Seven cyathostome species (*Cylicocyclus nassatus, Cyathostomum catinatum, Cylicostephanus longibursatus, Cylicostephanus goldi, Cylicocyclus ashworthi, Cylicostephanus calicatus* and *Cylicocyclus leptostomus*) were dominant in the strongylid community; they were found in more than 75 % of the horses examined and constituted 90.75% of the total strongylid number.

According to prevalence values, all strongylid species (33) were ranged in 10 prevalence classes (0–10 %, ... 91–100%). The number of taxa corresponding to each prevalence class was determined (fig. 3). The shape of the prevalence frequency distribution of the strongylid species appeared to be multimodal with dominant background and rare species.

***Regional peculiarities of strongylid communities in domestic horses from separate regions of Ukraine***

For the analysis of regional peculiarities of horse strongylid communities, we divided horses into five groups according to the regions: northern (Kyivska and Sumska oblasts), southern (Khersonska oblast and Crimea), western (Ternopilska and Zakarpatska oblasts), eastern (Kharkivska and Donetska oblasts) and central (Kyrovogradska and Poltavska oblasts).

The richest biodiversity of strongylid community was registered in horses from the southern region of Ukraine. Twenty-nine strongylid species from 12 genera were found there: 22 species of Cyathostominae and seven of Strongylinae. From 5 to 23 species (13.9 ± 4.1 SD) parasitized each horse. The shape of the prevalence frequency distribution of the strongylid species appeared to be multimodal.

Twenty-eight strongylid species from 11 genera were found in horses from the northern region: 22 species of Cyathostominae and 6 of Strongylinae. From 6 to 20 species (11.54 ± 3.9 SD) parasitized each horse. The shape of the prevalence frequency distribution of the strongylid species was also multimodal.

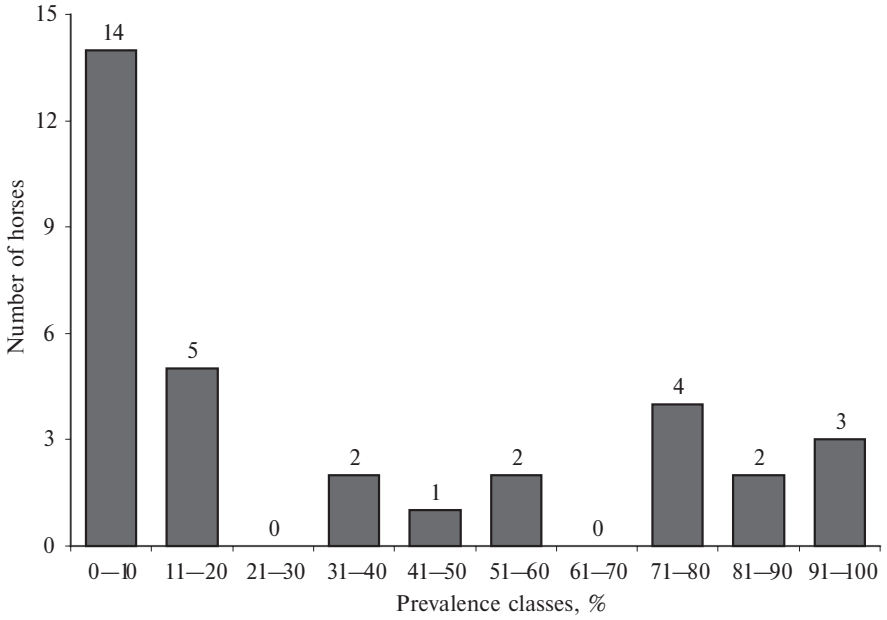


Fig. 3 Prevalence frequency distribution of 33 strongylid species found in domestic horses of Ukraine.

Рис. 3. Частота распределения 33 видов стронгилид, обнаруженных у домашних лошадей Украины по классам экстенсивности инвазии.

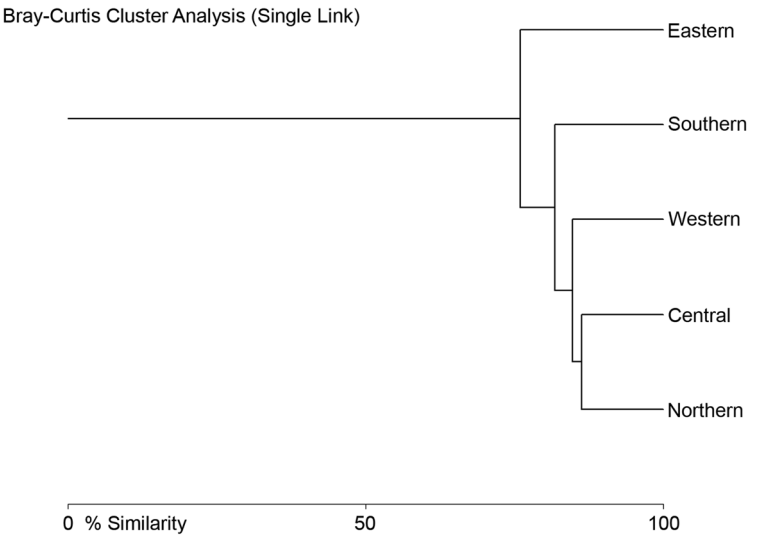


Fig. 4. Bray–Curtis cluster analysis of similarity of strongylid communities in domestic horses from various regions of Ukraine.

Рис. 4. Кластерный анализ сходства сообществ стронгилид домашних лошадей из разных регионов Украины по Bray–Curtis.

Twenty-one strongylid species from 11 genera were found in horses from the western region: 19 species of Cyathostominae and two of Strongylinae. From 5 to 16 species (9.39 ± 2.9 SD) parasitized each horse. The shape of the prevalence frequency distribution of the strongylid species was multimodal.

Twenty-three strongylid species from 11 genera were found in horses from the central region: 19 species of Cyathostominae and 4 of Strongylinae. From 5 to 16 species (9.29 ± 2.5 SD) parasitized each horse. The shape of the prevalence frequency distribution of the strongylid species was bimodal — background species (with prevalence from 31% to 60%) were absent in the strongylid community.

The biodiversity of strongylid community in horses from the eastern region of Ukraine was the lowest: only 15 strongylid species from six genera were found there — 13 species of Cyathostominae and three of Strongylinae. From 5 to 10 species (6.85 ± 1.4 SD) parasitized each horse. The shape of the prevalence frequency distribution of the strongylid species was multimodal; however, the group of subdominant species was absent in the community.

Bray–Curtis cluster analysis revealed similarity of strongylid communities in horses from the northern and central regions of Ukraine; strongylid community of horses from the eastern region differed sharply from those of the other regions (fig. 4).

On the other hand, there were no statistically significant differences found in species composition of strongylid communities in horses from five regions of Ukraine ($U = 431.5 — 511$; $z = 0.82 — 1.17$; $p > 0.05$).

**Comparison of strongylid communities of horses in Ukraine and other countries**

A total of 44 strongylid species were registered in domestic horses worldwide; all having cosmopolitan distribution. The number of strongylids found in domestic horses from various countries varied from 20 to 35 species (table 1).

Comparison of our data on biodiversity of the strongylid community in domestic horses in Ukraine with those in other countries (table 1) did not reveal apparent geographical variability in the strongylid communities.

**Table 1. Analysis of the similarity of strongylid communities in domestic horses from Ukraine and other countries**

**Таблица 1. Анализ сходства сообществ стронгилид домашних лошадей Украины и других стран**

| Country, region | Number of species | % of total-number | Chekanovsky-Sørensen Index ($I_{C\text{-}S}$) | Mann-Whitney test (U) | |
|---|---|---|---|---|---|
| | | | | U | p |
| **Ukraine**, present study | 33 | 75.0 | — | — | — |
| **Ukraine** (Dvojnos, Kharchenko, 1994) | 34 | 77.3 | 0.90 | 986 | 0.81 |
| **Poland** (Gawor, 1995) | 30 | 68.2 | 0.92 | 902 | 0.48 |
| **Czech Republic** (Baruš, 1962) | 35 | 79.5 | 0.94 | 924 | 0.62 |
| **France** (Collobert-Laugier et al 2002) | 22 | 50.0 | 0.73 | 770 | 0.046 |
| **UK** (Ogbourne, 1976; Ogbourne, Duncan, 1985) | 24 | 54.5 | 0.77 | 771 | 0.043 |
| **USA**, Ohio (Reinemeyer, et al., 1984) | 27 | 61.4 | 0.80 | 836 | 0.17 |
| **USA**, Kentucky (Lyons et al., 1996; Tolliver, 2000) | 28 | 63.6 | 0.82 | 858 | 0.25 |
| **USA**, Louisiana (Chapman et al., 2002) | 32 | 72.7 | 0.86 | 946 | 0.80 |
| **Brazil**, Rio de Janeiro (Anjos, Rodrigues, 2003) | 28 | 63.6 | 0.85 | 828 | 0.24 |
| **South Africa** (Krecek et al., 1989) | 20 | 45.5 | 0.68 | 682 | 0.004 |
| **Australia**, Queensland (Mfitilodze, Hutchinson, 1990) | 35 | 79.5 | 0.85 | 946 | 0.71 |
| **Australia**, Victoria (Bucknell et al., 1995) | 31 | 70.5 | 0.87 | 922 | 0.63 |

Bray–Curtis cluster analysis revealed similarity of strongylid communities in horses from Ukraine, Czech Republic, and Poland (fig. 5). Horses from South Africa had the most specific strongylid community.

## Discussion

In the present work, we present the results of complex analysis of the strongylid community data obtained in our parasitological studies in 10 regions of Ukraine between 2003—2009. Even though the helminthological material was collected over

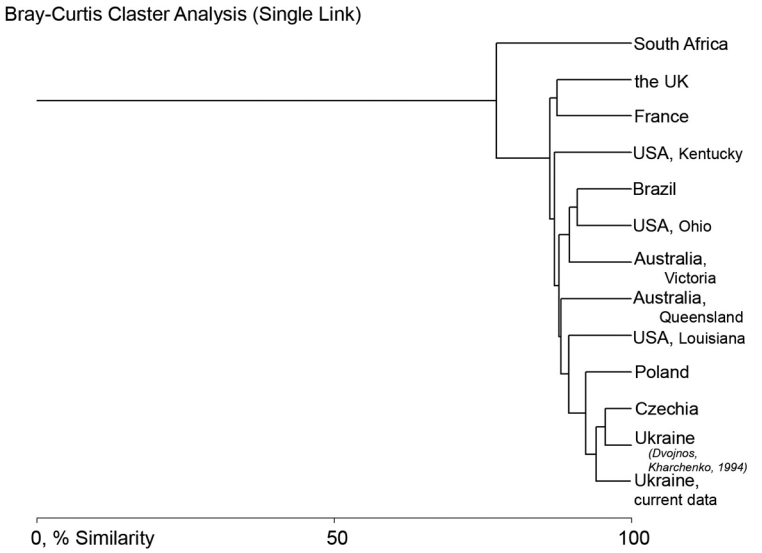


Fig. 5. Bray–Curtis cluster analysis of similarity of strongylid communities in Ukrainian domestic horses and horses from other countries.

Рис. 5. Кластерный анализ сходства сообществ стронгилид домашних лошадей Украины и других стран по Bray–Curtis.

seven years, all studies were performed with the same diagnostic deworming method (Kuzmina et al., 2004); this allowed the data comparison.

Thirty-three strongylid species from 12 genera were found in domestic horses in the present study. Previous researchers, who investigated species composition of strongylids in domestic horses in Ukraine in 1960–1970 of the 20th century (Ivashkin, Dvojnos, 1984; Dvojnos, Kharchenko, 1994) registered 34 species of strongylids. We did not find three rare species: *Oesophagodontus robustus* (Giles, 1892) Railliet and Henry, 1902 (subfamily Strongylinae), *Poteriostomum ratzii* (Kotlan, 1919) Yorke and Macfie, 1920, and *Parapoteriostomum euproctus* (Boulenger, 1917) Hartwich, 1986 (subfamily Cyathostominae). In our opinion, absence of these species in the present results is explained by reduction of biodiversity of the strongylid communities caused by regular deworming of domestic horses with macrocyclic lactone drugs (ivermectin, aversectin, moxidectin) during recent decades.

Our present results demonstrate that cyathostomes are predominant in strongylid communities in domestic horses from different regions of Ukraine; cyathostomes comprise 99.73 % of the total strongylid number. Our data correspond to the data of other researchers that found cyathostomes the most prevalent and important group of equine parasites (Herd, 1990; Love et al., 1999; Osterman Lind et al., 1999; Lyons et al., 1999; Konigova et al., 2001; Collobert-Laugier et al., 2002; Kaplan, 2002; Corning, 2009). A decrease in the proportion of large strongyles among the horse strongylids in Ukraine during the past 40 years was registered previously (Kuzmina et al., 2005) and, in our opinion, it also was the result of a widespread application of highly effective modern anthelmintics.

The shape of the prevalence frequency distribution of the strongylids in domestic horses was mainly multimodal, with dominant, subdominant, background, and rare species. All horses examined were kept on horse farms with different systems of anthelmintic deworming programs (from rare treatment — not more than once a year, or frequent treatments — 3–4 times per year). Previous studies on the influence of anthelmintic treatments on horse strongylid community structure proved that bimodal structure of community ("core-satellite" mode) was the result of frequent deworming in domestic equids (Bucknell et al., 1996; Osterman Lind et al., 2003; Kuzmina et al., 2005; Kuzmina, Kharchenko, 2008; Kuzmina, Kuzmin, 2008). Rare species with low prevalence and intensity are quickly eliminated from the community, and the background and some of the subdominant species take their place. Dominant cyathostome species, that presumably have high genetic diversity necessary to survive the strong selection pressure of anthelmintic treatments, continue their dominance in the strongylid community (Kuzmina, Kharchenko, 2008).

Analysis of regional peculiarities of strongylid biodiversity revealed a decrease in species richness of the strongylid community in domestic horses from eastern regions of Ukraine. In our opinion, this decrease can be caused by a more continental climatic condition in the eastern Ukraine (comparatively dryer summer and colder, frosty winter) as well as by a difference in horse-keeping conditions. Nowadays, small private horse farms with small grazing facilities predominate in the eastern Ukraine compared with others regions. Horses usually are kept under stable or stable-paddock conditions on these farms and are dewormed frequently (more than 3–4 times per year). In our opinion, increasing strongylid biodiversity in the southern regions of Ukraine is connected to favourable climatic conditions (warm winters) that allowed strongylid free-living larvae to survive on pasture for a long time and successfully infect grazing horses from the first days of pasture season.

However, statistical analysis did not reveal significant differences in species composition of strongylid communities in domestic horses from separate regions of Ukraine ($p > 0.05$). In our opinion, this is because there is a general similarity in the natural

and climatic conditions in the moderate zone of Ukraine. Similarity of strongylid communities in horses from Ukraine, Czech Republic, and Poland confirm this assumption.

Strongylid communities in Ukrainian horses significantly differ from those of horses from north-western Europe (France and the UK) and South Africa. No significant differences in strongylid communities were found between horses from moderate climatic zones of North and South America and Australia. In our opinion, this similarity in strongylid communities is connected both to similar climatic conditions and to traditional systems of horse management in those countries.

The results obtained in the present study affirm the similarity of species composition of horses, strongylid communities in different regions of Ukraine. Similarity of strongylid communities in domestic horses from various countries of the world indicates that, despite differences in nature and climatic zones in various countries and continents, the systems of horse management are the main factor that influences the biodiversity of strongylid communities. Therefore, investigation of biodiversity of parasites in wild and domestic horses from regions with pasture free-roaming horse keeping systems (Central and Southeast Asia or Africa) or from high-mounting areas of Central and Lesser Asia are of special interest for the equine parasitologists.

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