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BIOECOLOGICAL FEATURES OF *IXODES PERSULCATUS* AND *DERMACENTOR RETICULATUS* IN NATURAL AND ANTHROPOGENIC DISTURBED TERRITORIES OF KEMEROVO REGION

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Abstract

Currently, active dispersal and successful colonization meadow tick (*Dermacentor reticulatus*) continues in new territories of West Siberia due to the faster period of development of individuals of this species in comparison with *Ixodes persulcatus*, which indicates it as potentially the most widespread and numerically superior to all other ixodes ticks of the pasture-lying type. The bioecological features of *D. reticulatus* give it significant dominant advantages over other ixodid mites that pose an epidemiological danger, even over *I. persulcatus* in terms of the development of newly emerging biogeocenoses, which confirmed by our own long-term data from field collections of flag.

Keywords: ixodes ticks, epidemiological danger, distribution, bioecological features, disturbed areas, Kemerovo Region.

КЕМЕРОВ ОБЛЫСЫНЫҢ ТАБИҒИ ЖӘНЕ АНТРОПОГЕНДІК ТҰРҒЫДАБҰЗЫЛҒАН АУМАҚТАРЫНДА *IXODES PERSULCATUS* ЖӘНЕ *DERMACENTOR RETICULATUS* БИОЭКОЛОГИЯЛЫҚ ЕРЕКШЕЛІКТЕРІН САЛЫСТЫРУ

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Аңдатпа

Қазіргі уақытта Ixodes persulcatus тайга кенелерімен салыстырғанда осы түрдің жылдам дамуына байланысты жаңа аумақтарда шабындық кененің (Dermacentor reticulatus) көп қоныстануы және кең таралуы байқалады, бұл оның жайылымдық типтегі барлық басқа иксодикалық кенелерден ең көп таралғаны және сандық жағынан жоғары екенін көрсетеді. D. reticulatus биоэкологиялық ерекшеліктерінің арқасында эпидемиологиялық қауіп төндіретін басқа да иксодикалық кенелерден, соның ішінде I. persulcatus-тан айтарлықтай басым артықшылықтарға ие. Бұл шабындық кененің адам әрекетінен бұзылған биогеоценоздарға тез енуінен көрінеді, бұл біздің жалауша әдісімен далалық егін жинау бойынша көпжылдық деректерімізбен расталады.

Кілт сөздер: иксодикалық кенелері, эпидемиологиялық қауіп, таралу, биоэкологиялық ерекшеліктер, бұзылған аумақтар, Кемерово облысы.

БИОЭКОЛОГИЧЕСКИЕ ОСОБЕННОСТИ *IXODES PERSULCATUS* И *DERMACENTOR RETICULATUS* НА ЕСТЕСТВЕННЫХ И АНТРОПОГЕННО НАРУШЕННЫХ ТЕРРИТОРИЯХ КЕМЕРОВСКОЙ ОБЛАСТИ

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Аннотация

В настоящее время наблюдаются активное расселение и успешная колонизация лугового клеща (*Dermacentor reticulatus*) на новых территориях в связи с более быстрым периодом развития особей этого вида по сравнению с таежным клещем *Ixodes persulcatus*, что указывает на него как на потенциально наиболее распространенного и численно превосходящего всех других иксодовых клещей пастбищного типа. Биоэкологические особенности *D. reticulatus* дают ему значительные доминирующие преимущества перед другими иксодовыми клещами, представляющими эпидемиологическую опасность, в том числе перед *I. persulcatus*. Это проявляется в быстром проникновении лугового клеща в нарушенные человеческой деятельностью биогеоценозы, что подтверждается нашими собственными многолетними данными по полевым сборам методом на флаг.

Ключевые слова: иксодовые клещи, эпидемиологическая опасность, распространение, биоэкологические особенности, нарушенные территории, Кемеровская область.

Introduction

Ixodes ticks are reservoirs and carriers of pathogens of many natural focal diseases, which usually classified into the group of "tick-borne infections". The following are of the greatest medical and veterinary importance among infections associated with ixodes ticks in Russia and neighboring countries: tick-borne encephalitis, Omsk hemorrhagic fever, ixodes tick-borne borreliosis, anaplasmosis (including human granulocytic anaplasmosis), Crimean hemorrhagic fever, ehrlichiosis (including human monocytic ehrlichiosis, rickettsiosis, babesiosis and tularemia [1].

In recent decades, *D. reticulatus* has attracted increasing attention from researchers: it is becoming one of the most widespread and most active species of ticks of the pasture-lying type. It is also one of the most significant facilities in the context of assessing the epidemiological situation in the Kemerovo Region (Kuzbass).

Every year, more and more cases of ixodic tick bites of wild and domestic mammals, birds, and humans are recorded [2]. Most of the scientific papers on ixodid mites in the Kemerovo region were published in the 1960s and 70s, and later works were mostly medical rather than bioecological in the content. Many authors have noted significant changes in the ranges of some ixodid mite species [1], which also makes it necessary to conduct research clarifying the current ranges, the ratio of abundance and periods of activity for these species, especially in densely populated areas of the region.

This article is devoted to the analysis of numerical data on the results of long-term field collecting of ixodids by the flagging method in various territories of Kuzbass, as well as to the consideration of the development and seasonal activity of *I. persulcatus* and *D. reticulatus* as the most common ixodid ticks that pose a danger to humans.

Material and methods of study

The imago of male and female ixodid ticks were collected using the traditional method on the flag. Accounting routes were laid for the collection and accounting of imago of pasture ticks. A GPS tracker was been used to accurately monitor the route traveled. The universal accounting unit was the collected number of ticks per flag in terms of 1 km of the route (ex/km). The main device for collecting ticks was a standard travois or flag, which consists of a stick and, usually used as a direct place of capture of the tick, a white waffle cloth with a standard size of 60x100 cm. The identification of the species was carried out according to the methodological recommendations for the identification of ixodid mites in Western Siberia, given in the monograph by Yakimenko V.V. [1].

In 2019-2021, tick counts were carried out in the Kuznetsk forest–steppe (the green suburbs of Kemerovo and the village of Yagunovo, Kemerovo region, on the territory of the lowland black taiga village of Osinovka), in the forest territories of Kuznetsk Alatau, Salair and Gornaya Shoria (the cities of Mezhdurechensk and Novokuznetsk, as well as settlements of the Novokuznetsk region - the village of Listvyagi, the vicinity of the railway station Polosukhino, the neighborhood of the village Kuzedeevo, and the village of Perekhlyai, Krapivinsky district), in the territories of the Mariinsk-Achinsk forest–steppe (Tyazhinsky district – Tyazhinsky village and Danilovka village, Chebulinsky district - Shestakovo village).

In 2019, together with the staff of the Department of Ecology and Nature Management of Kemerovo State University (KemSU), 208.97 km of the registration route were completed and 2,524 Ixodidae family ticks were collected.

In 2020, 89.85 km was covered and 550 ticks were collected. Ticks counts were held on 23 routes in Kemerovo, Chebulinsky, Mezhdurechensky and Tyazhinsky districts. In 2021, a study was conducted at 11 points in Kuzbass in the Kemerovo region, Novokuznetsk and Tyazhinsky with a total route length of 44.72 km, during which 265 ticks were collected. All the collected acarological material was determined and systematized jointly with the staff of the Department of Ecology and Nature Management of KemSU.

The results of the study and discussion

The staff of the Department of Ecology and Nature Management of Kemerovo State University, together with the authors, conducted field research in various settlements of the Kemerovo region in the spring and summer of 2019. The average number of taiga ticks in various localities was 6.9 (±2.6) specimens./km2. At the same time, there is evidence of a significantly higher number of ticks. Thus, in the suburbs of the Malopeschanka village in the Mariinsky district, a zone with a population of 218.6 taiga ticks/km2 was identified.

Monitoring of the number of ixodes ticks in Tyazhinsky district in the period 2020-2022 showed a high degree of dominance of *I. persulcatus* in relation to *I. pavlovskiy*. The abundance of *I. persulcatus* in the area of the Azhendarovo biological station on the animal trail, which is used mainly by European moose or elk *(Alces alces* Linnaeus, 1758) and less often by brown bears (*Urus arktos* Linnaeus, 1758), was 8.4 specimens/km in early May 2017, and only 2.0 specimens/km at the end of June. During the study period, this trail was used by three moose and one brown bear.

According to previously published data, *I. pavlovskiy* is in second place in the Kemerovo region in terms of population and prevalence. The first evidence of the discovery of the Pavlovsky tick on the territory of the Kuznetsk-Salair mountain region is 1970 discovery in the south of the Kemerovo region in the suburbs of Mezhdurechensk city [3].

Ticks of the *I. pavlovskiy* type were defined by acarologists as *I. persulcatus* due to the hybridization of the two species and often the presence of similar morphological characteristics,

which complicates their demarcation during investigation with materials on Kuzbass in earlier works [4, 5].

The meadow tick (*D. reticulatus*) is an important object of research in the field of ecology and biology, especially in the context of its distribution and impact on human and pet health. This species of mite was first described in 1794 under the name *Acarus reticulatus* (Fabricius, 1794). It is a carrier of various diseases, inhabits new territories and has a number of ecological advantages in comparison with other ixodes mites.

The Kuznetsk-Salair region, with its diverse ecosystems and climatic conditions, provides unique opportunities for field research of the meadow tick, its biology and ecology. The biotopic distribution of the meadow tick varies slightly in different landscape subzones. In the northern forest-steppe, *D. reticulatus* is most confined to the edges of birch groves, inter-forested meadows, and ribbon forests. It inhabits inter-forested areas to a lesser extent. In the southern forest-steppe, it is distributed along the edges of birch spikes, meadows and roadsides; in the steppe zone, it prefers sparse birch spikes and forest belts; in the forest–steppe of the right-bank Ob region, priority zones are the edges of mixed and deciduous forests, deforestation; in the foothill forest-steppe, settlements and river valleys. The wide range of *D. reticulatus* also includes swampy mixed forests, river basins, and coastal vegetation [6].

At the turn of the 20th and 21st centuries, the meadow tick began to be regularly recorded in field collections of ixodid ticks of the pasture-lying type in the Leninsko-Kuznetsky, Krapivinsky and Kemerovo districts of Kuzbass. *D. reticulatus* is one of the three most widespread and numerous ixodids in the region. The relative abundance of meadow mites in a number of field collections for travois reached 38.5 specimens/km2, which is quite high relative to other tick species in the suburbs of Kemerovo in 2017. The distribution of *D. reticulatus* in the urban area is characterized by a characteristic mosaic pattern. According to research data from previous years, the share of meadow mites was less than 1% of the total harvest in the region [7]. Our own long-term research data indicate that every year the share of *D. reticulatus* in the collections of all ticks of the pasture-lying type increases and already amounts to about 35%, depending on the landscapes. Meadow ticks are regularly removed from domestic dogs in the city of Kemerovo. The extreme northeastern location of the tick is currently noted in the Mariinsky district [8].

The western slopes of the Kuznetsk Alatau are the eastern boundary of the range of this species [9]. Some authors in their works point to the expansion of *D. reticulatus* in the eastern and southern directions [1]. This is confirmed by our research data, namely, the discovery of *D. reticulatus* in the suburbs of the Myski town, where it had not previously been observed, during comprehensive ecological and faunal field studies.

As mentioned earlier [9], in the south of Western Siberia, the meadow tick becomes more active in April-May, that is, in early spring immediately after the snow cover melts. In the taiga zone *D. reticulatus* has a one-year-long development cycle. It can overwinter repeatedly, and enter summer diapause in July [10]. In the case of an early and warm spring, the maximum number is recorded at the end of April, and in the case of a prolonged spring – in the second or third decade of May. In the first decade of June, the number of imago drops sharply, in July they practically do not occur, having entered a state of summer imaginal diapause. In the second decade of August, the second peak of the tick population begins. In different years, the peak number is observed in the third decade of August and early September, and isolated cases of tick activity are noted until mid-October. In comparison with the spring, the number of ticks halved during the autumnal activity, and stopped after the appearance of snow [11, 12]. As a rule, imago overwinter hungry, but this type of tick is also characterized by wintering on the body of wild and large domestic mammals in a slightly drunk or hungry state. In spring,

additional nutrition occurs quickly and clutches are produced at an earlier time than in ticks that have wintered in the litter in a hungry state. Unlike the taiga tick, mating of the meadow tick usually occurs on the body of the host. In the taiga mite, the first mating occurs both on the body of the host and outside it without a clear advantage to one or another variant [9, 13].

For all males of the genus Dermacentor, blood feeding is a prerequisite for the completion of spermatogenesis. The amount of absorbed blood in males is noticeably less than in females, but this fact is not an obstacle to effective transmission of pathogens of vector-borne infections during blood sucking. A female meadow tick lays up to 7,200 eggs when drunk [14]. The larvae are active from the end of April to the beginning of October; their mass appearance occurs in June. The peak number of larvae occurs in the third decade of June or the second decade of August. The larvae feed for 3-4 days and molt into nymphs very quickly. Nymphs, in turn, are active from early July to mid-September; their maximum activity in the third decade of July and the first decade of August are observed; the feeding time is similar to that of the larvae. The life span of hungry individuals varies from 25 to 50 days, then hungry larvae and nymphs die in winter. In the conditions of Western Siberia in general, and the Kemerovo region in particular, the entire development cycle of the meadow tick takes 110-115 days, that is, it ends during one spring–summer season [11].

At all stages of development, the host feeders of the meadow tick are mainly mammals, there are 55 species in Western Siberia; imago are fed by large and medium–sized mammals, mainly domestic and wild ungulates, larvae and nymphs are small mammals. The main feeders of larvae and nymphs in the region are: the water vole *Arvicola terrestris* (Linnaeus, 1758), the common hamster *Cricetus cricetus* (Linnaeus, 1758), the field mouse *Apodemus agrarius* (Pallas, 1771) and the narrow-crunched vole *Microtus gregalis* (Pallas, 1779) [9]. Cases of adult males of *D. reticulatus* wintering on Siberian roe deer *Capreolus pygargus* (Pallas, 1771) [15, 16], as well as domesticated reindeer *Rangifer tarandus* (Linnaeus, 1758) have been recorded.

On February 1, 2018, more than one hundred ticks were found in the neck area of Kemerovo, 32 individuals were transferred for identification. The result showed that all the transferred ticks are males of the meadow tick *D. reticulatus.* Earlier [17], a similar case of wintering of females and males of various species of the genus Dermacentor on livestock in Western Siberia was described.

As an adaptation to imago feeding on large animals that inhabit open spaces, ticks of this species have developed the following adaptations:

– for the use of one individual host by a large number of ticks, ambush occurs in groups of several individuals;

– the ticks extend not one, as the taiga tick does, but three pairs of legs towards the approaching potential feeder;

– finds of meadow mites on birds are regarded as very rare and are random.

Our surveys allowed us to obtain the most up-to-date information about the acarological situation in previously unexplored territories. This is especially important in connection with the increasing frequency of complaints from local residents about tick bites of the pasture-lurking type. The analysis of the research results allowed us to obtain up–to-date data on the species diversity and the ratio of ixodid mites in Kuzbass in territories belonging to 3 types of habitat in the region - the Kuznetsk forest-steppe, the Mariinsk-Achinsk forest-steppe, as well as in the forests of the Kuznetsk Alatau, Salair and Gornaya Shoriya (Table 1).

Table 1. Occurrence of ticks in the studied territories in 2019 – 2021

Habitat type	Species	Number of ticks	Length of routes	Sp/km	Territory disturbance
Kuznetsk forest-steppe	*Ixodes persulcatus* (Schulze, 1930)	240	44,36	5,41	Natural
Kuznetsk Alatau, Gornaya Shoria, Salair	*Dermacentor reticulatus* Fabricius, 1794	3	3,4	0,88	Natural
Kuznetsk Alatau, Gornaya Shoria, Salair	*Ixodes persulcatus* (Schulze, 1930)	56	40,41	1,39	Natural
Mariinsk-Achinsk forest-steppe	*Ixodes persulcatus* (Schulze, 1930)	91	9,58	9,50	Natural
Kuznetsk forest-steppe	*Dermacentor reticulatus* Fabricius, 1794	1883	149,47	12,60	Disturbed
Kuznetsk forest-steppe	*Ixodes persulcatus* (Schulze, 1930)	170	127,1	1,38	Disturbed
Kuznetsk Alatau, Gornaya Shoria, Salair	*Dermacentor reticulatus* Fabricius, 1794	669	20,25	33,04	Disturbed
Kuznetsk Alatau, Gornaya Shoria, Salair	*Ixodes persulcatus* (Schulze, 1930)	11	13,63	0,81	Disturbed
Mariinsk-Achinsk forest-steppe	*Ixodes persulcatus* (Schulze, 1930)	12	15,57	0,77	Disturbed

During the studies of the natural territories of the Kuznetsk forest-steppe in the vicinity of the village of Osinovka, the abundance of *I. persulcatus* was 5.41 specimens/km. No ticks of the species *D. reticulatus* have been found in collections from the natural territories of the Kuznetsk forest-steppe have been found. As for the territories of the Kuznetsk forest-steppe that are anthropogenic disturbed or affected by emissions from enterprises (62-proezd, Kazachiy Tract, Rudnichny and Serebryany Bor of Kemerovo, Yagunovo village), the abundance of ticks of the species *D. reticulatus* was 12.6 specimens/km, and I. persulcatus 1.38 specimens/km, respectively. The data indicate that *D. reticulatus* has successfully gained a foothold and dominates in the city limits of Kemerovo and in reclaimed territories, with the exception of pine forests, where I. persulcatus remains the dominant species.

Studies conducted in natural areas in Tyazhinsky district have shown that the abundance of *I. persulcatus* is 9.5 specimens/km. No other ixodid species have been found in natural areas. In the anthropogenic disturbed territories of the Chebulinsky and Tyazhinsky districts, which were characterized by sparse vegetation cover, as well as pollution caused by emissions from industrial enterprises, the abundance index of *I. persulcatus* was 0.77 specimens/km. No ticks of the *D. reticulatus* species were recorded here.

Collections on the anthropogenically disturbed landscapes of Kuznetsk Alatau and Gornaya Shoria (in Novokuznetsk district, in the vicinity of the railway station Polosukhino, recultivation of the surroundings of the village of Kuzedeevo and the village of Listvyagi, as well as the surroundings of the city of Mezhdurechensk) allowed us to establish the species diversity and abundance of ixodids.

According to the results of the studies conducted here, the abundance of *D. reticulatus* is 33.04 specimens/km, *I. persulcatus* is 0.81 specimens/km. *I. persulcatus* and its "twin species"

I. pavlovskiy were recorded on the reclamation dumps of coal mines. In the uncultivated landscapes of the village of Listvyagi and natural areas of the Krapivinsky district of the village of Perekhlyai (secondary forests), the abundance of *I. persulcatus* was 1.39 specimens/km, *D. reticulatus* – 0.88 specimens/km. This shows an extremely high difference in the ratio of the number of specimens per kilometer of *D. reticulatus* ticks in natural and anthropogenic territories in comparison with *I. persulcatus.*

Studies of the Kuznetsk forest-steppe, the Mariinsk-Achinsk forest-steppe, as well as the forests of the Kuznetsk Alatau and Gornaya Shoria have made it possible to establish the relative abundance of ixodes ticks, which pose a real epidemiological danger in the Kemerovo Region in 2021. The highest abundance index in the Kuznetsk forest-steppe based on studies of disturbed territories was noted for *D. reticulatus* (12.6 specimens/km), and in natural areas - *I. persulcatus* (5.41 specimens/km). In the Mariinsk-Achinsk forest-steppe, only *I. persulcatus* was found on natural landscapes (9.50 copies/km). In undisturbed forests of the Kuznetsk Alatau and Gornaya Shoria, *I. persulcatus* has the highest abundance of 1.39 specimens/km, in atropogenously disturbed land *I. persulcatus, I. pavlovskiy,* and *H. concinna* occur equally, and no obvious dominance of any species has been identified.

Conclusion

An analysis of previously published data and the results of our own research in the Kemerovo region shows that meadow and taiga mites are widespread species, sometimes reaching extremely high numbers, which have a wide range of feeders among both birds and mammals. Our research has made it possible to clarify the current state of the territories of the Kemerovo region in terms of the presence of two of the most common and numerous species of ixodes ticks, which pose a real epidemiological danger. It is necessary to continue monitoring the number of ixodids of the pasture-lying type in order to track the expansion of epidemiologically dangerous species and, most importantly, on newly emerging biogeocenoses – coal mine dumps, secondary forests after man-made disasters and the like. The fragmentary dominance of *D. reticulatus* over *I. persulcatus* in anthropogenic-disturbed territories was noted, which makes it possible to classify this species as one of the potential bioindicators in an industrial region. In natural areas that are not significantly affected by anthropogenic influences, I. persulcatus remains the most common among ixodes ticks of the pasture-lying type in the Kemerovo Region.

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