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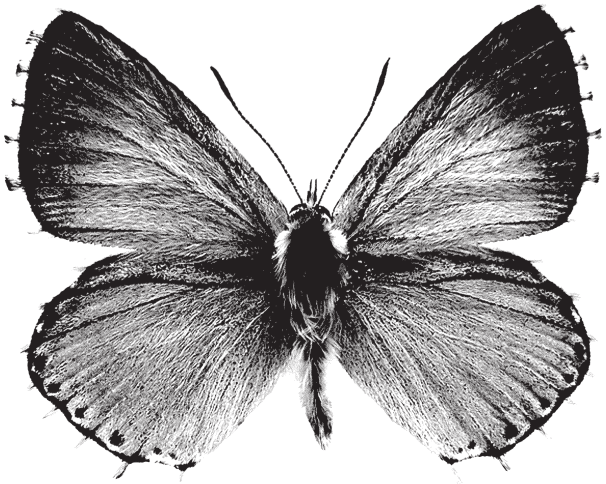

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Diversitiy of oribatid mites (Acari, Oribatei) and other soil microarthropods in plumage of raptors

Разнообразие панцирных клещей (Acari: Oribatei) и других почвенных микроартропод в оперении хищных птиц и сов

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Key words: soil microarthropods, oribatid mites (Acari: Oribatei), bird's plumage, birds of prey (Facloniformes), owls (Strigiformes)
Ключевые слова: орибатиды (Acari: Oribatei), почвенные микроартроподы, оперение птиц, хищные птицы (Facloniformes), совы (Strigiformes)

Abstract. Data on the soil microarthropod fauna, including oribatid mites (Acari: Oribatei), inhabiting the plumage of 114 individuals of 21 species of eagle and falcon and six species of owls from 33 locations in Eurasia and Northern Africa are presented. From between 0 to 71 of individuals of non-parasitic microarthropod were recorded on a single bird. On average there were 4,8±8,6 (±standard deviation) microarthropods, and 2,2±3,0 oribatid mites per bird. The composition of non-parasitic soil microarthropods in the plumage of the studied group of birds was: 44% – oribatid mites (28% of them were adult mites, 14% – nymph and 3% – larvae), 23% – gamasid mites, 18% – collembolans, 8% – prostigmata mites, 3% – acaridia mites, 2% – Bdellidae and 1% – small spiders and larvae of beetles. There was no correlation between number of individuals and species of non-parasitic microarthropods in the plumage and the size of bird, although such a tendency had been observed earlier for anceriformes birds. From one to 12 speies of oribatid mites were recorded from different species of raptor. The recorded number of oribatid mite taxa on different species of birds was dependent on the sample size of the studied birds. In total 60 species of oribatid mites from 13 genera were found in the plumage of raptors. About 80% of all recorded species of oribatid mites were found in the plumage in an adult stage, however juvenile stages of 19 species of oribatid mites were also recorded on raptors. Different age stages of four species (*Diapterobates humeralis, D. notatus, Platynothrus peltifer* and *Tectocepheus velatus*) were found in the plumage of one bird which can indicates reproduction of these oribatid mite species in bird feathers. The majority of oribatid mite species (86%) recorded in the plumage are widely distributed in Palearctic soils. However, for some species of southern oribatid mite there is a probable northerly dispersal route by birds from a steppe zone to a zone of broad-leaved woods and taiga (*Suctobelba ladaria, Peloribates longipilosus*) but also southwards from more northern areas of the Far East to the more southern areas of Mongolia (*Suctobelbella opistodentata*) is possible. The role of raptors in the distribution of soil microarthropods is discussed.

Резюме. В статье анализируются данные о почвообитающих микроартроподах, в том числе панцирных клещах или орибатидах (Acari: Oribatei), обнаруженных в оперении 114 особей 21 вида хищных птиц и 6 видов сов из 33 пунктов Евразии и Северной Африки. На птицах обнаружено от 0 до 71 экз. непаразитических микроартропод. На одной птице находили в среднем по 4,8±8,6 (±стандартное отклонение) экз. микроартропод и 2,2±3,0 экз. орибатид. В оперении исследуемой группы птиц состав непаразитических почвенных микроартропод был следующим: 44% орибатид, из них 28% взрослых клещей, 14% нимф и 3% личинок, 23% гамазид, 18% ногохвосток, 8% простигматических, 3% хлебных, 2% краснотелковых клещей и 1% мелких пауков и личинок жуков. Не обнаружена связь между количеством экземпляров и видов непаразитических микроартропод в оперении и размерами птиц, как это было выявлено ранее для гусеобразных. На разных видах хищных птиц и сов найдено от 1 до 12 видов орибатид. Количество выявленных для разных видов птиц таксонов орибатид зависело от величины выборки обследованных птиц. Приведен список таксонов орибатид: 60 видов и 13 родов, – найденных в оперении. Около 80% всех обнаруженных видов панцирных клещей были встречены в оперении во взрослой стадии. На хищных птицах и совах обнаружены преимагинальные стадии 19 видов орибатид, а разные возрастные стадии 4-х видов (*Diapterobates humeralis, D. notatus, Platynothrus peltfer* и *Tectocepheus velatus*) встречены в оперении одной птицы, что может свидетельствовать о размножении этих видов орибатид в перьях. Большинство из встреченных в оперении видов панцирных клещей (86%) широко распространены в почвах Палеарктики. Однако для некоторых видов орибатид показан возможный занос птицами южных видов из степной зоны в

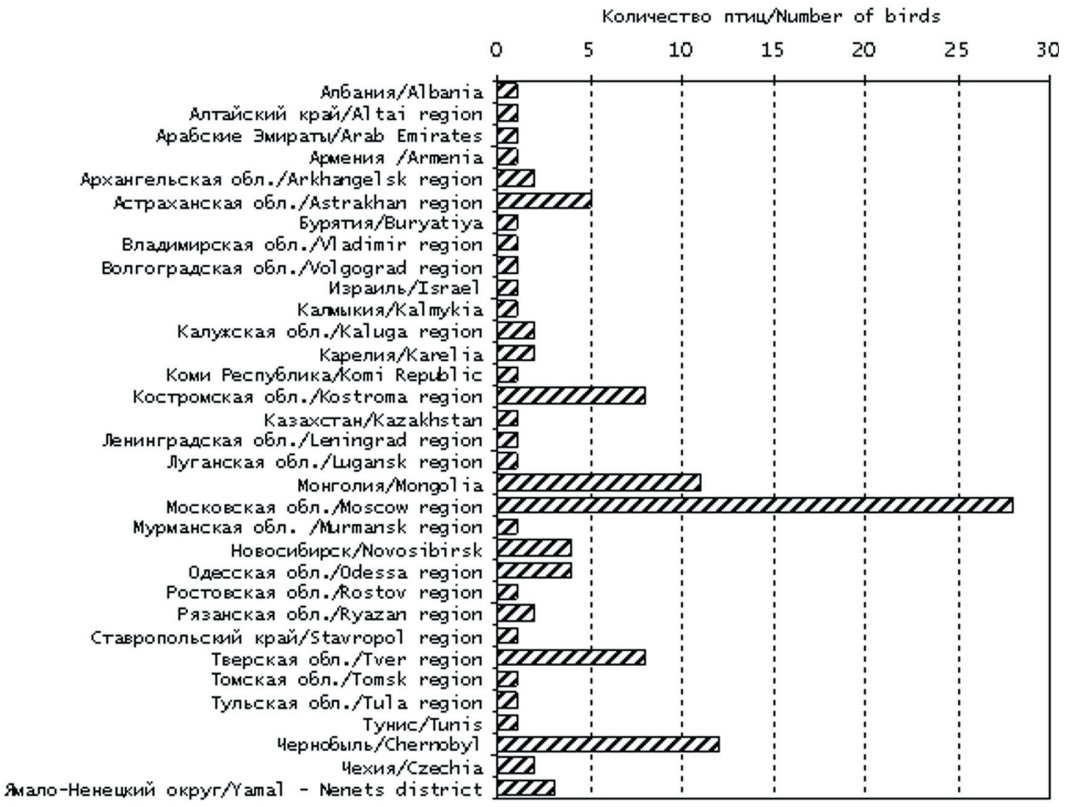

Fig.1. Geographic distribution of number of observed raptors.
Рис. 1. Географическое распределение количества обследованных хищных птиц и сов.

широколиственные леса и тайгу (*Suctobelba lapidaria, Peloribates longipilosus*) и, наоборот, из более северных районов Дальнего Востока в более южные широты Монголии (*Suctobelbella opistodentata*). Анализируется роль хищных птиц и сов в распространении почвенных микроартропод.

Introduction

As part of the soil-forming process, soil microarthropods, including oribatid mites (Acari, Oribatei), play a significant role in terrestrial ecosystems [Krivolutsky, 1995]. Their species diversity in different areas of the Earth, taxonomy, biology, ecology, and evolution are the focus of attention of world soil zoology and acarology [Schatz, 2004; Krantz, Walter, 2007]. Many of the peculiarities of their distribution over the planet were generally explained by the continental drift [Hammer, Wallwork, 1979; Wallwork, 1984], glacial processes, as well as by the physical transport through the geographical barriers by means of water and wind [Coulson et al. 2002]. Nonetheless, recent investigations based on the examples of the remote islands of the Arctic have demonstrated the transport of soil microarthropods by birds [Lebedeva, Krivolutsky, 2003].

The observation of the use of birds plumage as a substrate by the soil biota was reported at the end of XX – beginning of XXI centuries [Krivolutsky, Lebedeva, 1999; 2003; Krivolutsky, Lebedeva, 2004 a,b et al.], nonetheless the diversity of soil microarthropods in the plumage of many bird groups remains unstudied. In our previous publications we demonstrated that birds connected with water biotopes (sea-birds, water-fowl and shorebirds) may play a great role in the distribution of soil microarthropods, transporting the microarthropods in the feathers. Since terrestrial microarthropod species generally prefer wet habitats they are able to naturalize swiftly in other geographic zones following such dispersal [Lebedeva, 2005; Lebedeva et al., 2006; Lebedeva, Lebedev, 2007]. Of current importance is the evaluation of the role of other groups of birds in the transport of soil microarthropods which still, though to a lesser extent, are connected to marine and freshwater ecosystems but which are more widely spread in arid and semi-arid landscapes. Examples of such birds are birds of prey and owls (raptors). Raptors have a different cutaneous cover as compared to the other groups of birds. Since they do not have permanent or periodic contact with water, except for some fish-eating species, their skin is drier, and their plumage is less dense as compared with that of the waterfowl and seabirds. Thus, it can be hypothesised that raptors may have a poorer microarthropod fauna in their plumage and consequently their role in soil biota distribution may be less significant than that of the anceriformes. Nevertheless, many raptors rest on the ground or build massive nests out of the plant material and thus be contact with a substrate from which they can acquire soil microarthropods.

The main objective of the present research was to analyze the diversity of soil microarthropods and oribatid mites in the plumage of raptors in particular, as well as to estimate their role in soil microarthropod distribution in different geographic zones.

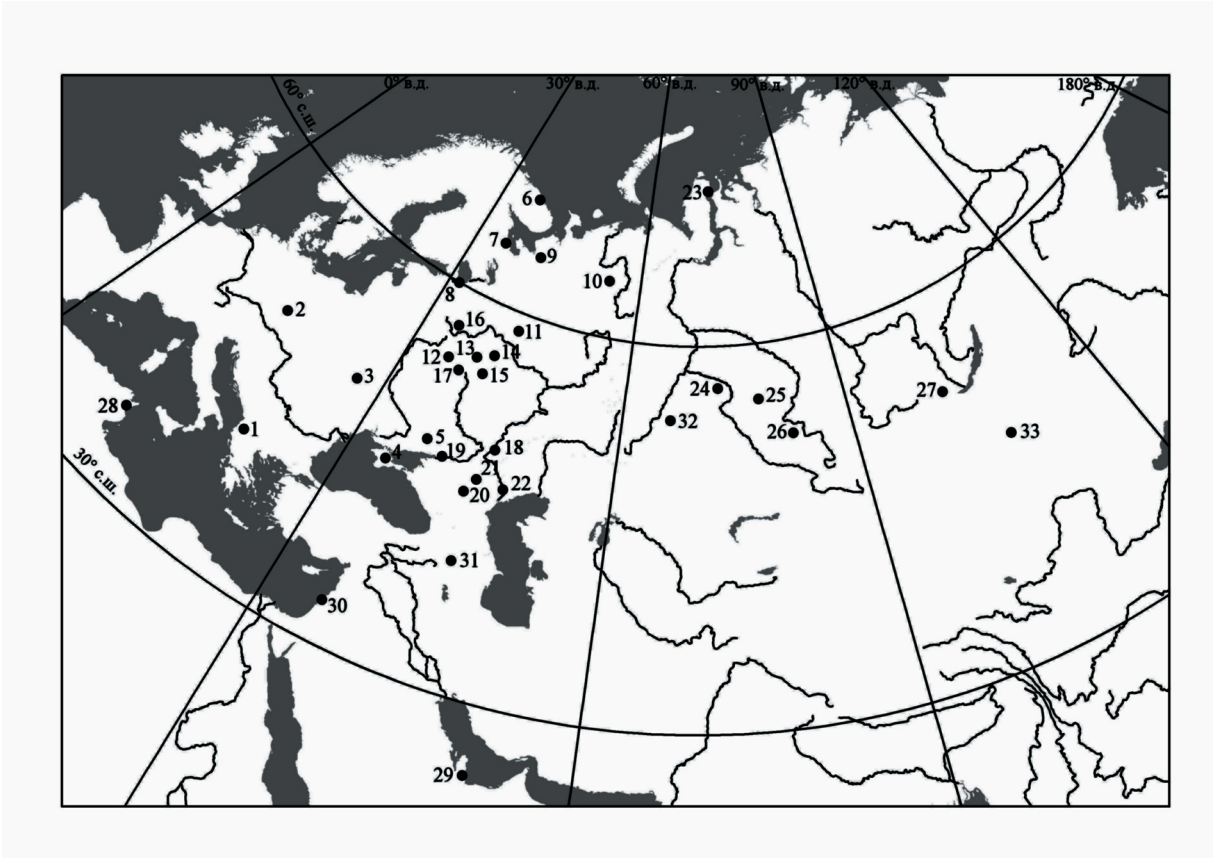

Fig.2. Map of birds of prey and owls collecting points. Digital designations of points of collecting are the following: Europe: 1 – Albania; 2 – Czechia; 3-5 – Ukraine (3 – Chernobyl, 4 – Odessa region, 5 – Lugansk region); Russia: 6 – Murmansk region; 7 – Karelia; 8 – Leningrad region; 9 – Arkhangelsk region; 10 – Komi Republic; 11 – Kostroma region; 12 – Kaluga region; 13 – Moscow region; 14 – Vladimir region; 15 – Ryazan region; 16 – Tver region; 17 – Tula region; 18 – Volgograd region; 19 – Rostov region; 20 – Stavropol territory; 21 – Kalmykia; 22 – Astrakhan region; 23 – Yamal – Nenets district; 24 – Tomsk region; 25 – Novosibirsk; 26 – Altai region; 27 – Buryatiya; Africa: 28 – Tunis; Asia: 29 – Arab Emirates; 30 – Israel; 31 – Armenia; 32 – Kazakhstan; 33 – Mongolia.

Рис.2. Карта мест сбора хищных птиц и сов. Цифровые обозначения мест сбора следующие: Европа: 1 – Албания; 2 – Чехия; 3-5 – Украина (3 – Чернобыль, 4 – Одесская обл., 5 – Луганская обл.); Россия: 6 – Мурманская обл.; 7 – Карелия; 8 – Ленинградская обл.; 9 – Архангельская обл.; 10 – Коми Республика; 11 – Костромская обл.; 12 – Калужская обл.; 13 – Московская обл.; 14 – Владимирская обл.; 15 – Рязанская обл.; 16 – Тверская обл.; 17 – Тульская обл.; 18 – Волгоградская обл.; 19 – Ростовская обл.; 20 – Ставропольский край; 21 – Калмыкия; 22 – Астраханская обл.; 23 – Ямало-Ненецкий округ; 24 – Томская обл.; 25 – Новосибирск; 26 – Алтайский край; 27 – Бурятия; Африка: 28 – Тунис; Азия: 29 – Арабские Эмираты; 30 – Израиль; 31 – Армения; 32 – Казахстан; 33 – Монголия.

Materials and methods

Birds of prey (Facloniformes) and owls (Strigiformes) were collected between 1999 and 2004. Practically all the species belonging to the aforementioned families in Russia and other countries are under legal protection and therefore their collecting for further studies of their plumage depended on accidental circumstances, namely the death of birds on high-voltage lines, collisions with lighthouses, posts, motor transport, etc. Among the examined raptors there were also injured nestlings, having fallen out of the nests. Another set of studied individuals included several species of hawks and harriers obtained from hunters during spring and autumn fowling, as well as birds being shot in the vicinities of the airport landing strips. Additionally several dead birds were obtained from bird of prey nurseries while others were specially obtained during the Russian-Mongolian expedition works and in Chernobyl during further radio-ecological investigations and studies of heavy metal accumulation. All this explains the heterogeneity of the obtained material aimed for the study (Fig.1).

Thus, most of the birds were obtained from Sheremetyevo Airport (Moscow, Russia), Mongolia and Chernobyl (Ukraine). The map (Fig. 2) shows the birds sampling points.

114 individuals of 21 species of Facloniformes, and six species of Strigiformes were studied: the Osprey *Pernis apivorus*, the Black kite *Milvus migrans*, the Marsh harrier *Circus aeruginosus*, the Hen harrier *C. cyaneus,* Montagu's harrier *C. pygargus*, the Goshawk *A. gentilis,* the Sparrowhawk *A. nisus*, the Buzzard *Buteo buteo*, the Rough-legged buzzard *B. lagopus*, the Upland buzzard *B. hemilasius,* the Golden eagle *Aquila chrysaetos*, the Tawny eagle *A. rapax*, the White-taied eagle *Haliaeetus albicilla*, the Black vulture *Aegypius monachus*, the Gyrfalcon *Falco rusticolus*, the Saker *F. cherrug*, the Hobby *F. subbuteo*, the Red-footed falcon *F. vespertinus*, the Amur falcon, *F. amurensis*, the Lesser kestrel *F. naumanni*, the Kestrel *F. tinnunculus*, the Long-eared owl *A. otus*, the Short-eared

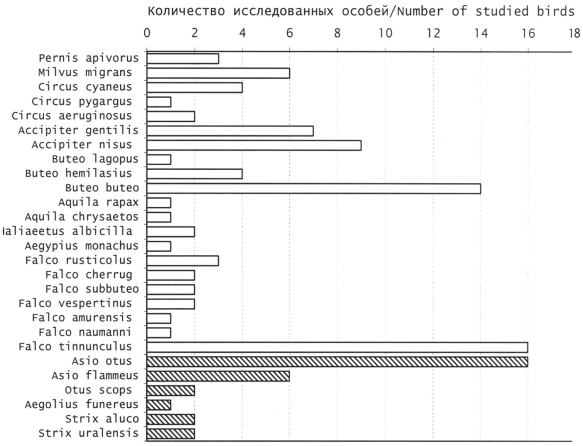

Fig. 3. Species and number distributions of studied Facloniformes (white columns) and Strigiformes (pattern columns) (N=114).

Рис.3. Видовой и количественных состав обследованных хищных птиц (белые столбики) и сов (заштрихованные столбики) (N=114).

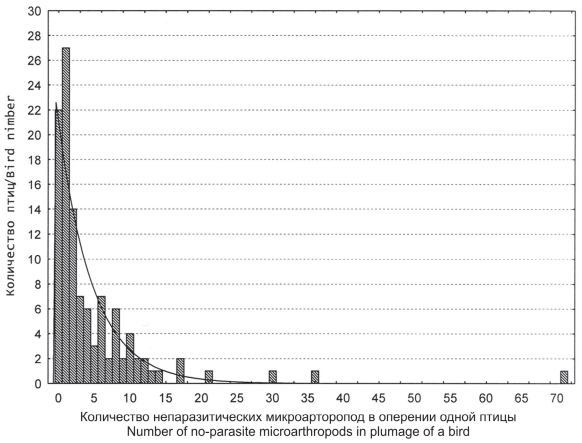

Fig. 4. Number distribution of nonparasitic soil microarthropods in a plumage of raptors.

Рис. 4. Распределение количества непаразитических почвенных микроартропод в оперении хищных птиц и сов.

owl *A. flammeus*, the Scops owl *Otus scops*, the Boreal owl *Aegolius funereus*, the Tawny owl *S. aluco*, the Ural owl *S. uralensis*. The number of the studied birds is presented in Fig. 3

The skins of the birds were cut into sections and placed feathers down in Berlese-Tullgren modified funnels and kept under an electric lamp for 3-4 days. Microarthropods, extracted from the plumage were fixed in 70% ethanol with addition of glycerol. Soil microarthropods were identified by †D.A.Krivolutsky or under his supervision.

Results

Twenty percent of individuals belonging to 14 bird species from different geographical zones did not possess soil microarthropods in their plumage. Oribatid mites were not found in the plumage nearly one third of all the examined 16 bird species. Other birds were marked by the presence of one to 71 individuals of soil microarthropods and from one to 13 individuals of oribatid mites (Fig. 4).

Microarthropods were found in the plumage of all investigated species of raptor and oribatid mites were also recorded from the plumage of all species, except for the Scops owl. The maximum number of non-parasitic soil microarthropods (71) was found on a Long-eared owl from the Astrakhan region, the greater part being represented by the predatory gamasid mites (69). In the plumage of several individuals of some bird species, such as the Kestrel from Moscow, Upland buzzard from Mongolia, Long-eared owl from the Tver region, there were 36, 30 and 21 soil microarthropod individuals, respectively. The plumage of the Lesser kestrel from Kalmykia possessed the maximum number of oribatid mites, i.e. 13 examples; while 12 oribatid mites were observed on a Upland buzzard in Mongolia, the Goshawk in Chernobyl and in the Kestrel from Moscow. However, on the whole, the number of non-parasitic microarthropods, inparticular oribatid mites, in the plumage of any one bird, was low. On average, there were 4,8±8,6 (± standard deviation) individuals of microarthropod and 2,2±3,0 individuals of oribatid mite, respectively. The median values were equal to 2 and 1 individuals respectively. On the whole, the distribution of soil microarthropods in birds feathering demonstrated a correlation with a Poisson distribution, characterizing rare events.

The composition of soil microarthropods, having found in the plumage of the raptors is presented in fig. 5.

Oribatid mites were the most numerous group in the plumage of raptors. Non-parasitic gamasid mites and collembolans comprised 20 to 25% of all observed soil microarthropods (N=551). The abundance of prostigmatid mites was also great compared to the smallest number in the Acaridae and Bdellidae. Larvae of beetles, small spiders and copeognatha were occasionally observed but their contribution to the total fauna was small at approximately 1%. The correlation between different groups of microarthropods in the plumage of raptors was close in birds from the coasts of the Barents Sea and the neighbouring islands and did not differ significantly (χ^2=8,11; df=5; p= 0,15 NS).

Species diversity of oribatid mites varied among different birds from 1 to 14 species (Fig. 6).

Each of the seven species of bird of prey demonstrated only one species of oribatid mite; the maximum number of these microarthropod species (14) was found in the plumage of the Buzzard, while 13 species were collected from the plumage of the Goshawk and Sparrowhawk. The highest number of oribatid mite species (10) was recorded in the Long-eared owl when compared to other owl species. However, the species diversity of the oribatid mites depended on the sample size (r=0.75, N=27) (Fig. 7).

The species composition of the oribatid mites from the plumage of raptors is presented in appendix A. 60 species and 13 genera of oribatid mites have been determined. About 80% of all observed species of oribatid mite were adult. In the plumage of birds of prey and owls larval stages of 19 oribatid species were observed eg. Achipteridae, *Camisia spinifer, Diapterobates notatus, Nothrus palustris*, *Platynothrus peltifer* and undetermined oribatid mites. These larvae comprised 3% of all soil microarthropods in the plumage.

Nymphs of different ages (proto-, deuto- and triponymphs) *Camisia* sp., *Camisia horrida*, *Diapterobates humeralis*, *Hermannia* sp., *Hermannia scabra*,

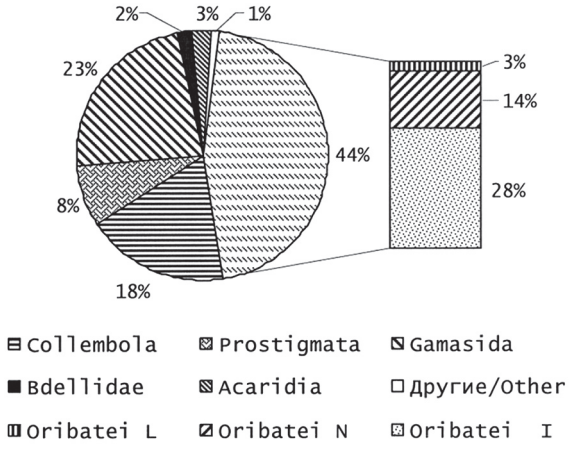

Fig. 5. Distribution (composition) of nonparasitic soil microarthropods found in the plumage of raptors.

Рис. 5. Состав почвенных непаразитических микроартропод, найденных в оперении хищных птиц и сов (N=551).

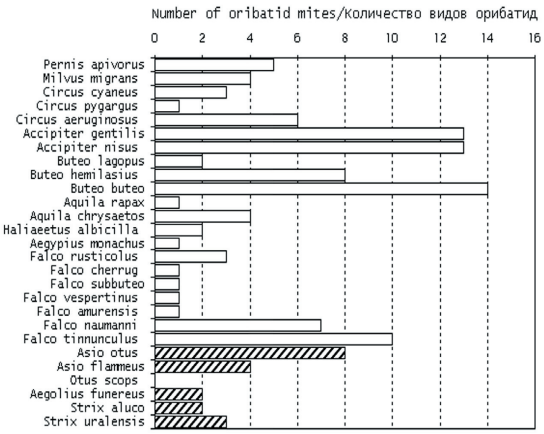

Fig.6. Number of oribatid mite species found in the plumage of different species ofraptor.

Рис.6. Количество видов панцирных клещей, найденных в оперении разных видов хищных птиц и сов

Nanhermannia sp., *Parachipteria punctata*, *Poroliodes farinosus*, *Tectocepheus velatus*, *Trhypochthonius tectorum* and *Scheloribates laevigatus* comprised 14% of all non-parasitic microarthropods found in plumage (Fig. 5). Such species as *Diapterobates notatus*, *Nothrus palustris* and *Platynothrus peltifer* were noted in the plumage as both larvae and nymphs while and adults were also recorded for *Platynothrus peltifer*. Different age stages of four oribatid species (*Diapterobates humeralis, D. notatus, Platynothrus peltifer* and *Tectocepheus velatus*) have been observed in the plumage of one bird; this may be evidence of the reproduction of these species of the oribatid mite in the given substrate (Tabl. 1). It is necessary to note that the majority of these species are parthenogenetic, for example, *Camisia spinifer, Platynothrus peltifer Diapterobates notatus, Hermannia scabra, Nothrus palustris, Tectocepheus velatus* and *Trhypochthonius tectorum* (Norton, Palmer, 1991, Cianciolo, Norton, 2006). Thus, it is likely that some species of oribatid mite reproduce in the plumage of the Osprey, Gyrfalcon, Goshawk, Sparrowhawk, Upland buzzard and Ural owl from different geographical zones (tundra, boreal and steppe zones).

The distribution of occurrence frequency of oribatid species in different species of raptors showed that only several species of the oribatid mites are frequently met in the plumage (Fig. 8).

The most widely distributed microarthropods in the plumage of birds of prey and owls appeared to be the species with high natural population densities in the different geographical zones, among them are *Tectocepheus velatus* (in 12 species), *Oppiella nova* (in 7 species), *Discoppia splendens* и *Carabodes areolatus* (in 6 species) и *Moritzoppia unicarinata* (in 5 species). The majority of oribatid species (47 species) were recorded only once from one bird species, 20 species of the oribatid mites were observed in the plumage of two bird species.

Most of the oribatid mites (86%) recorded are widely distributed throughout palearctic soils. However, there are some interesting observations, for example *Suctobelba lapidaria*, earlier registered only for the Rostov region [Krivolutsky, 1995], was found in the plumage of the Kestrel from the Moscow region and in the Long-eared owl from the Tver region. *Peloribates longipilosus*, the southern species and typical for the steppe zone [Krivolutsky, 1995], was found in the plumage of the Goshawk from the Republic of Komi, which is evidence of possible transport of some southern oribatid species by the birds of prey from the steppe zone to the broad-leaved forests and on to the taiga. Of particular interest is the find of *Suctobelbella opistodentata* in the feathering of the Saker from Mongolia. Previously, this mite was only recorded from the north of the Far East [Krivolutsky, 1995]. This mite could travel to more southerly Mongolian latitudes via bird dispersal.

Of further interest is the discovery of *Haplochthonius simplex*. This is quite a rare species having been recorded from the soils of the Rostov and Orenburg regions [Krivolutsky, Kazadaev, 1976; Krivolutsky, 1995]. Recently, it has been found in the nests of the Saker in Ukraine (Odessa, zoological gardens) [Krivolutsky, Lebedeva, 2003]. It is rather abundant in the vicinity of Astrakhan, where it was found in the plumage of three bird species, among them are Sparrowhawk, Red-footed falcon, and Kestrel. *Tropacarus pulcherrimus*, having been previously recorded from the territory of Russia (Sochi and Daghestan soils) [Krivolutsky, 1995], was found in the feathering of the Black kite and Upland buzzard from Mongolia.

DISCUSSION

The analysis of recent data on the diversity of soil microarthropods and oribatid mites in the plumage of birds of prey and owls shows that the plumage of these birds contains the same groups of soil microarthropods as that of anceriformes [Lebedeva, 2005]. However, the population densities of soil microarthropods and oribatid mites in the raptor plumage was lower when compared to their abundance on big swans and geese. Consequently, the plumage of raptors is inhabited by soil microarthropods (and oribatid mites) to a lesser degree than that of anceriformes and other species connected with water habitats. Possibly,

Table 1. Reproduction of oribatid mites that in a plumage of raports were registered: L – larvae, N – nymph, N1 – protonymph, N2 – deutonymph, N3 – tritonymph, I – adult mites.

Таблица 1. Панцирные клещи, размножение которых отмечено на хищных птицах и совах, где L – личинка, N – нимфы, N1 – протонимфа, N2 – дейтонимфа, N3 – тритонимфа, I – взрослый клещ.

Oribatid mites species/ Виды орибатид	Age stages of oribatid mites found on a bird/ Возрастные стадии, найденные на одной птице	Bird species / Виды птиц
Diapterobates humeralis (Hermann, 1804)	N, I	Osprey
Diapterobates notatus (Thorell, 1872)	L, N1	Ural owl
Platynothrus peltifer (C.L. Koch, 1839)	N2, I	Sparrowhawk
Tectocepheus velatus (Michael, 1880)	N2, N3 N, I N1, I	Gyrfalcon Upland buzzard Goshawk

the plumage of raptors is less favourable for oribatid mites and other microarthropods due to the skin dryness and relative ″looseness″ of the feathers. However, the diversity of soil microarthropods in the plumage of raptors was similar with their diversity in the plumage of the Barents Sea birds [Lebedeva et al, 2006]. The same groups of soil microarthropods dominate in plumage of raptors as these in plumage of seabirds and waders inhabiting high latitudes of the Arctic.

A connection between the number of individuals and species of non-parasitic microarthropods in the plumage and the size of the birds, as was stated earlier for anceriformes, has not been found [Lebedeva, 2005]. This is likely to be due to the fact that large species of birds of prey were, as a rule, isolated specimens. It was not always possible to use the fresh skin of the birds and birds were occasionally frozen to preserve the material prior to examination. This might cause some mortality amongst the microarthropods and result a discrepancy.

The list of oribatid mite taxa, recorded in the plumage of raptors numbers some 60 species from 13 genera. For such a small sample size of studied birds such diversity seems rather impressive. The list of oribatid mites turned out to be substantially enhanced due to the 100% increase in the number of studied raptors as compared to the previous data [Krivolutsky, Lebedeva, 2003]. The number of observed oribatid taxa for different bird species depended on the sample size of the examined birds. Apparently, continued studies in this field will produce an even greater list of oribatid mites in the future.

Between one to 12 species of oribatid mites have been observed in the plumage of raptors. Larval stages have never been recorded for 80% of oribatid species found in the plumage. However, for 19 species of other oribatid species it may be assumed that they can reproduce directly in the plumage, since these species were represented by larvae and/or nymphs of different ages. Moreover, both larvae and nymphs of four species of oribatid mites, such as *Diapterobates humeralis, D. notatus, Platynothrus peltifer* and *Tectocepheus velatus* were recorded in the plumage of one bird, which is evidence of the reproduction of these oribatid species in the feathers.

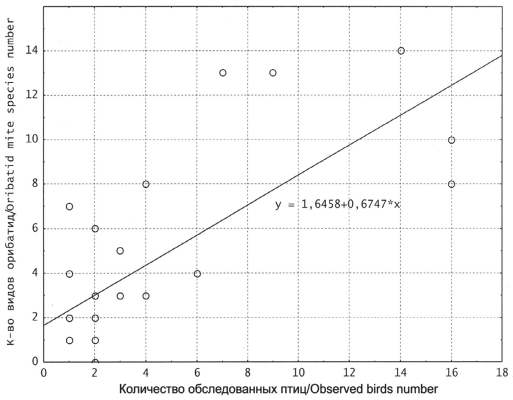

Fig. 7. Dependence of number of found species of oribatid mites from sampling value of different species of raptor.

Рис. 7. Зависимость количества выявленных видов панцирных клещей от величины выборки разных видов хищных птиц и сов (N=27).

As it may be seen from Appendix A, the diversity of mature/adult oribatid mites in the plumage of day birds of prey was great. One can note a high diversity of the representatives of epifauna, namely oribatid mites of a relatively large size: *Hermannia, Nothrus, Camisia, Platynothrus, Belba, Gustavia, Cepheus, Trichoribates, Poroliodes, Fuscozetes, Parachipteria, Pergalumna, Neoribates.* Small oribatids like *Oppia, Suctobelbella, Liochthonius* comprised only 17% of the individuals (N=263). In addition, their immature stages were not found. This fact testifies to accidental character of inhabiting raptor plumage of oribatid mite species, that we cannot identify any species of mites which would be found even in only half of the observed birds.

However, birds of prey, though to a lesser extent than seabirds, waterfowl and shore-birds, possess an accidental and rather diverse fauna of soil microarthropods and can fulfill a transport function. As long as the birds of prey have lengthy migration routes, they can transport soil biota in their plumage from different geographical zones and

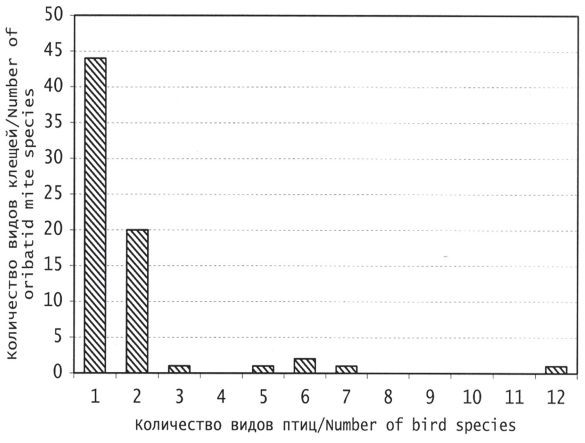

Fig. 8. Occurrence frequency distribution of oribatid mite species in different species of raptor.

Рис. 8. Распределение числа видов орибатид в зависимости от количества видов хищных птиц и сов, в оперении которых они найдены

influence the formation of the soil fauna community. This principle may be illustrated by the our study. Southern species of oribatid mite, such as *Suctobelba lapidaria*, *Peloribates longipilosus*, may be transported by the birds from the steppe zones to the forest and taiga. The transport of the mites by the birds from the North to the South may be shown by the example of Suctobelbella opistodentata, living in the Russian Far East being transported to the southern latitudes of Mongolia.

The majority of oribatid mite species, found in the plumage of birds of this group are distributed widely in palearctic soils (Appendix A). This is likely to happen owing to the birds, the plumage of which may be used by many oribatid mite species as a temporary dwelling substrate. Both eurybiontic character and their reproductive strategies promote this ability.

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Appendix A. Taxa list, distribution, age stage of oribatid mites. Sites of raptors collection, in which plumage oribatid mites were founde.
Приложение А. Таксономический список, распространение, стадии развития панцирных клещей, места сбора хищных птиц и сов, в оперении которых они обнаружены.

Taxon/ Таксон	Distribution[a]/ Распространение	Age stages (number of individuls)[b] / Стадии развития (кол-во экз.)	Bird collecting sites[c]/ Места сбора птиц	Bird species[d] / Виды птиц
Hypochthoniidae				
Hypochthonius rufulus C.L. Koch, 1835	Palearctic	I(3)	16, 18	6, 23
Haplochthoniidae				
Haplochthonius simplex (Willmann, 1930)	Rostov region, Orenburg region	I(12)	22	7, 17, 21
Brachychthoniidae				
Brachychthonius berlesei Willmann, 1928	Palearctic	I(1)	19	13
Liochthonius sellnicki (Thor, 1930)	Palearctic	I(3)	23	15
Phthiracaridae				
Atropacarus striculus C.L. Koch, 1836	Palearctic	I(8)	13, 21	20, 21
Phthiracarus borealis (Trägårdh, 1910)	Palearctic	I(1)	13	7
Phthiracarus globosus	Palearctic	I(1)	21	20
Phthiracarus sp.		I(11)	13, 33	7, 9, 13
Steganacarus sp.		I(1)	33	9
Tropacarus carinatus (C.L. Koch, 1844)	Palearctic	I(2)	16, 21	5, 20
Tropacarus pulcherrimus Berlese, 1885	Sochi, Dagestan	I(2)	33	2, 9
Euphthiracaridae				
Euphthiracarus sp.		I(1)	13	22
Nothridae				
Nothrus biciliatus C.L. Koch, 1844	Palearctic	I(1)	33	9
Nothrus palustris C.L. Koch, 1839	Palearctic	L(2), N(2)	13, 16. 33	5, 7, 9, 23
Camisiidae				
Camisia horrida (Hermann, 1804)	Palearctic	N(1)	33	9
Camisia sp.		N(1)	33	19
Camisia spinifer (C.L.Koch, 1835)	Palearctic	L(1)	32	7
Platynothrus peltifer (C.L. Koch, 1939)	Palearctic	L(1),N(1), I(1)	9, 13, 18	6, 7
Trhypochthoniidae				
Trhypochthonius tectorum (Berlese, 1896)	Palearctic	N(1)	12, 16	5, 22
Malaconothridae				
Malaconothrus egregius Berlese, 1904	Palearctic	I(2)	16, 21	20, 23
Malaconothrus sp.		I(1)	18	6
Nanhermanniidae				
Nanhermannia sp.		N(1)	33	12
Hermanniidae				
Hermannia scabra (C.L. Koch, 1839)	Palearctic	N(1)	32	7
Hermannia sp.		N(1)	3	2
Hermanniellidae				
Hermanniella granulata (Nicolet, 1855)	Palearctic	I(1)	14	10
Liodidae				
Poroliodes farinosus (C.L. Koch, 1839)	Palearctic	N(1)	9	7
Damaeidae				
Belba sp.		I(1)	3	7
Metabelba sp.		I(1)	16	22
Cepheidae				

Taxon/ Таксон	Distribution[a]/ Распространение	Age stages (number of individuls)[b] / Стадии развития (кол-во экз.)	Bird collecting sites[c]/ Места сбора птиц	Bird species[d] / Виды птиц
Cepheus cepheiformis (Nicolet, 1855)	Palearctic	I(1)	13	7
Eremaeidae				
Eueremaeus oblongus (C.L. Koch, 1835)	Palearctic	I(2)	13	10, 21
Eremaeus hepaticus (C.L. Koch, 1835)	Palearctic	I(1)	33	11
Eremaeus sp.		I(1)	33	9
Gustaviidae				
Gustavia microcephala (Nicolet, 1855)	Palearctic	I(1)	13	1
Xenillidae				
Xenillus tegeocranus Hermann, 1804	Palearctic	I(1)	33	12
Carabodidae				
Carabodes areolatus Berlese, 1916	Palearctic	I(6)	3, 11, 13, 21	1, 7, 10, 20, 22, 25
Carabodes forsslundi Sellnick, 1953	Palearctic	I(1)	13	13
Carabodes labyrinthicus (Michael, 1879)	Palearctic	I(1)	21	20
Tectocepheidae				
Tectocepheus velatus (Michael, 1880)	Palearctic	N(8), I(25)	3, 11, 13, 15, 16, 23, 24, 33	2, 3, 5, 6, 8, 9, 10, 12, 15, 21, 23
Autognetidae				
Autogneta willmanni (Dyrdowska, 1929)	Moscow region	I(2)	8	10
Oppidae				
Dissorhina ornata (Oudemans, 1900)	Palearctic	I(1)	13	7
Discoppia splendens (C.L.Koch, 1840)	Palearctic	I(7)	3, 13, 16, 18, 19	6, 7, 10, 13, 18, 22
Medioppia fallax (Paoli, 1908)	Kaliningrad region, Kandalaksha, Novgorod, Voronezh, Rostov, Volgograd regions, Tatrstan, Sakhalin	I(1)	16	22
Lauroppia maritima (Willmann, 1929)	Palearctic	I(1)	15	23
Microppia minus (Paoli, 1908)	Palearctic	I(1)	16	23
Moritzoppia unicarinata (Paoli, 1908)	Palearctic	I(6)	3, 11, 13, 30, 33	1, 6, 7,10, 14
Oppia sp.		I(1)	33	9
Oppiella nova (Oudemans, 1902)	Palearctic	I(12)	3, 8, 11, 13, 16	3, 5, 6, 10, 22, 23, 25
Oppiella sp.		I(2)	13, 16	5, 10
Quadroppiidae				
Quadroppia quadricarinata (Michael, 1885)	Palearctic	I(1)	3	6
Suctobelbidae				
Suctobelba lapidaria Moritz, 1970	Rostov region	I(2)	13, 16	4, 22
Suctobelba trigona (Michael, 1888)	Palearctic	I(2)	13	1, 3
Suctobelba sp.		I(5)	13	1, 10
Suctobelbella hammeri (Krivolutsky, 1966)	Palearctic	I(1)	23	8
Suctobelbella acutidens (Forsslund, 1941)	Palearctic	I(1)	3	6
Suctobelbella opistodentata (Golosova, 1970)	Far East	I(1)	33	16
Suctobelbella sp.		I(2)	13, 16	21, 22
Haplozetidae				
Peloribates longipilosus Csiszar, 1962	Rostov region, Nivorossijsk, Sochi, Orenburg region	I(1)	10	6
Oribatulidae				
Zygoribatula exilis (Nicolet, 1855)	Palearctic	I(5)	13, 14, 20	10, 21
Protoribatidae				

Taxon/ Таксон	Distribution[a]/ Распространение	Age stages (number of individuls)[b] / Стадии развития (кол-во экз.)	Bird collecting sites[c]/ Места сбора птиц	Bird species[d] / Виды птиц
Liebstadia similis (Michael, 1888)	Palearctic	I(1)	3	6
Scheloribatidae				
Scheloribates laevigatus (C.L. Koch, 1835)	Palearctic	N(1)	3, 11	2, 27
Scheloribates latipes (C.L. Koch, 1844)	Palearctic	I(2)	3, 24	2, 10
Parakalummidae				
Neoribates roubali (Berlese, 1910)	Moscow, Novgorod, Kursk, Voronezh regions, Sochi, Krasnoyarsk	I(1)	13	21
Ceratozeridae				
Ceratozetes cisalpinus Berlese, 1908	Palearctic	I(1)	21	20
Fuscozetes fuscipes (C.L. Koch, 1844)	Palearctic	I(1)	13	1
Diapterobates humeralis (Hermann, 1804)	Palearctic	N(1), I(1)	13	2
Diapterobates notatus (Thorell, 1871)	Palearctic	L(1), N(2)	11, 13	10, 27
Melanozetes mollicomus (C.L. Koch, 1839)	Palearctic	I(3)	13	21
Trichoribates trimaculatus (C.L. Koch, 1835)	Palearctic	I(2)	13, 25	15, 21
Chamobatidae				
Chamobates cuspidatus (Michael, 1884)	Palearctic	I(1)	11	27
Mycobatidae				
Minunthozetes pseudofusiger (Schweizer, 1922)	Palearctic	I(1)	18	6
Punctoribates punctum (C.L. Koch, 1839)	Palearctic	I(1)	3	26
Achipteriidae		L(1)		
Achipteria coleoptrata (Linnaeus, 1758)	Palearctic	I(1)	3	2
Parachipteria punctata (Nicolet, 1855)	Palearctic	N(1), I(1)	3	6
Galumnidae				
Pergalumna nervosa (Berlese, 1914)	Palearctic	I(2)	3, 13	10, 26
Oribatei (no determined)		L(7), N(52)	3, 7, 11, 13, 14, 16, 18, 25, 27, 33	1, 2, 6, 7, 9, 10, 12,19, 21, 22, 23, 26, 27

[a] Distribution by D.A. Krivolutsky (1995)

[b] Age stage of oribatid mites: L – larvae, N– nymph; I – adult mites.

[c] Sites of bird collections: see legend to Fig.2.

[d] Bird species: 1– the Osprey Pernis apivorus; 2– the Black kite Milvus migrans; 3– the Hen harrier Circus cyaneus; 4– the Montagu's harrier C. pygargus; 5–the Marsh harrier C. aeruginosus; 6–the Goshawk A. gentilis; 7– the Sparrowhawk A. nisus; 8– the Rough-legged buzzard Buteo lagopus; 9– the Upland buzzard B.hemilasius; 10– the Buzzard B. buteo; 11– the Tawny eagle Aquila rapax; 12– the Golden eagle A. chrysaetos; 13– the White-taied eagle Haliaeetus albicilla; 14– the Black vulture Aegypius monachus; 15– the Gyrfalcon Falco rusticolus; 16– the Saker F. cherrug; 17– the Hobby F. subbuteo; 18– the Red-footed falcon F. vespertinus; 19–the Amur Falcon F. amurensis; 20– the Lesser kestrel F. naumanni; 21– the Kestrel F. tinnunculus; 22– the Long-eared owl A. otus; 23– the Short-eared owl A. flammeus; 24– the Scops owl O. scops; 25– the Boreal owl A. funereus; 26– the Tawny owl S. aluco; 27– the Ural owl S. uralensis.

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