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Bark of *Ulmus laciniata* (Trautv.) Mayr in the diet of *Cervus elaphus xanthopygus* (Milne-Edwards)

D. A. Belyaev[1]✉, M. V. Maslov[2]

[1] Primorskaya State Academy of Agriculture, 44 Blucher Ave., 692510, Ussuriysk, Russia
[2] Federal Scientific Center of the East Asia Terrestrial Biodiversity, Far East Branch of the Russian Academy of Sciences, 159 Stoletiya Vladivostoka Ave., 690022, Vladivostok, Russia

Authors

Dmitry A. Belyaev
E-mail: d_belyaev@mail.ru
SPIN: 3237-0446
Scopus Author ID: 57219516418
ORCID: 0000-0001-7356-434X

Mikhail V. Maslov
E-mail: nippon_mvm@mail.ru
SPIN: 2706-2420
Scopus Author ID: 55620309700
ResearcherID: O-1072-2015
ORCID: 0000-0003-4193-7425

Abstract. Bark stripping by red deer has a significant impact on the state of forest ecosystems throughout the range of this ungulate species. Range-wide, red deer eat the bark of more than 20 species of trees, often causing significant damage to forestry. In the south of the Russian Far East, Manchurian red deer *Cervus elaphus xanthopygus* feed on the bark of elms *Ulmus* sp. in autumn and spring. However, prior research on the ecology of Manchurian red deer contains no quantitative estimates of the removal of elm bark by this ungulate. This article presents, for the first time, quantitative data on the influence of such deer feeding behavior on the forest stand of Primorsky Region. Manchurian red deer mainly damage undergrowth and young trees up to 40 years old with diameters of 0.5–7.4 cm at breast height (M = 3.75 ± 0.069, n = 249). In *Ulmus laciniata* undergrowth, the damaged bark area was 0.01–0.45 m^2 (M = 0.11 ± 0.096, n = 249). At the same time, the deer scraped more bark from large trees by area on average when converted to one tree.

Keywords: bark stripping, debarking, Primorsky Region, Russian Far East, Cervidae

Кора ильма лопастного *Ulmus laciniata* (Trautv.) в питании изюбря *Cervus elaphus xanthopygos* (Milne-Edwards)

Д. А. Беляев[1]✉, М. В. Маслов[2]

[1] ФГБОУ ВО Приморская государственная сельскохозяйственная академия, проспект Блюхера, д. 44, г. Уссурийск, 692510, Россия
[2] Федеральный научный центр биоразнообразия наземной биоты Восточной Азии Дальневосточного отделения Российской академии наук, пр-т 100-летия Владивостока, д. 159, 690022, г. Владивосток, Россия

Сведения об авторах

Беляев Дмитрий Анатольевич
E-mail: d_belyaev@mail.ru
SPIN-код: 3237-0446
Scopus Author ID: 57219516418
ORCID: 0000-0001-7356-434X

Маслов Михаил Вениаминович
E-mail: nippon_mvm@mail.ru
SPIN-код: 2706-2420
Scopus Author ID: 55620309700
ResearcherID: O-1072-2015
ORCID: 0000-0003-4193-7425

Аннотация. Обгладывание коры благородным оленем оказывает значительное влияние на состояние лесных экосистем по всему ареалу этого вида копытных. На всем протяжении своего ареала благородные олени употребляют в пищу кору более чем 20 видов деревьев, часто нанося значительный ущерб лесному хозяйству. На юге Дальнего Востока России изюбрь в осенне-весенний период питается корой ильмов *Ulmus* sp. Однако в научных работах, посвященных экологии изюбря, отсутствуют количественные оценки изъятия коры ильмов этим оленем. В нашей статье впервые приведены количественные данные по влиянию такого пищевого поведения оленей на древостой лесов Приморского края. Изюбрями в основном повреждается подрост и молодые деревья с диаметрами на высоте груди 0,5–7,4 см (m = 3,75 ± 0,069, n = 249) возрастом до 40 лет. Площадь повреждения коры подроста ильма лопастного составила 0,01–0,45 м^2 (m = 0,11 ± 0,096 м^2, n =2 49). С крупных деревьев изюбри при этом съедали больше коры по площади в среднем при пересчете на одно дерево.

Ключевые слова: поедание коры, ильм лопастной, Приморский край, Дальний Восток России, Cervidae

Introduction

In the forest ecosystems of Primorsky Region (the south of the Russian Far East), the condition of the "forest vegetation — ungulate browsers — large predators" food chain is most indicative of the stability of the entire ecosystem as a whole (Gaponov 2006). Wild species of the Cervidae family are not only the most important element of the forest ecosystems of the south of the Russian Far East, but also the main game in the region. Therefore, it is highly important to determine the ecologically optimal population density of wild ungulates, and research their relationship with forest vegetation. These animals are browsers: for most of the year, their diet consists mainly of shoots of trees and shrubs (Gaponov 2006). The diet composition of wild ungulates in the south of the Russian Far East as a whole and in the Primorsky Region particularly is presented in numerous publications and monograph chapters (Bromley, Kucherenko 1983; Chaus, Ignatova 2008; Danilkin 1999; Gaponov 1991; 2006; Kaplanov 1948; Kon'kov 2015; Mikhailovsky 1975; Makovkin 1999; Sheremetyev, Prokopenko 2005; 2006; Tsyndyzhapova et al. 2020). However, these works mainly discuss the winter browsing by various species of deer. Bark stripping, that is also part of deer feeding behaviour, is usually mentioned only in passing.

Bark stripping (debarking) is a feeding behaviour in which an animal removes and, as a rule, eats bark from the trunk and large branches of trees and undergrowth (Miquelle, van Ballenberghe 1989). This behaviour is prevalent among many species of the Cervidae family, primarily in the moose *Alces alces* L. and the red deer *Cervus elaphus* L. A fairly large number of publications have been devoted to this behaviour, as well as the influence of bark stripping on the state of the tree stand (Akashi, Nakashizuka 1999; Čermák et al. 2004; Dezhkin, Kaletsky 1973; Dinesman 1959; 1961; Dunin, Yanushko 1979; Gačić et al. 2012; Gębczyňska 1980; Gebert, Verheyden-Tixier 2001; Gill 1992a; 1992b; Kurek et al. 2019; Masuko et al. 2011; Mitchell et al. 1977; Michael 1987; Miquelle, van Ballenberghe 1989; Nevřelová, Ružičková 2015; Saint-Andrieux et al. 2009; Szukiel 1981; Verheyden et al. 2006; Vospernik 2006; White et al. 2003; Yevtushevsky, Mamenko 2013).

We have not been able to find any prior research devoted to the quantitative assessment of the removal of tree bark and the influence of such feeding behaviour of red deer on the forest stand of the Primorsky Region. The authors of publications usually simply state the fact that *Cervus elaphus xanthopygus* consume bark in the south of the Far East in early spring (Bromley, Kucherenko 1983; Danilkin 1999; Gaponov 1991; 2006; Kaplanov 1948; Mikhailovsky 1975). The purpose of our work was to conduct a qualitative and quantitative assessment of *Cervus elaphus xanthopygus* (Milne–Edwards, 1867) stripping bark of *Ulmus laciniata* (Trautv.) Mayr, 1906 in the south of Primorsky Region.

Study area

The research was carried out from April to June 2021 in the south of the Russian Far East (Primorsky Region) in the Ussuriysk urban district within the forest area of the Primorskaya State Academy of Agriculture, located in the vicinity of the Kamenushka village, Banevurovskoye district forestry (forest compartments # 52 and 53) (N 43°37′23″, E 132°13′50″) (Fig. 1).

On 11 April 2021, we discovered numerous *Ulmus laciniata* (Trautv.) Mayr with debarked trunks on the northern slope of the Komarovka River valley (height 170–270 m above sea level), with a large amount of *Cervus elaphus xanthopygus* winter droppings also present in the area. We investigated the site where elms with damaged bark were found. A sample plot was set here, with the area of 13 ha. The area was covered by Korean pine-deciduous forest of *Pinus koraiensis* Ziebold et Succ. (20%), *Betula costata* (Trautv.) (30%), *Fraxinus mandshurica* Rupr. (20%), *Tilia amurensis* Rupr., *T. mandshurica* Rupr. et Maxim. and *T. taquetii* C. K. Schneider. (20%), *Juglans mandshurica* Maxim. (20%), *Abies holophylla* Maxim., *Ulmus laciniata*

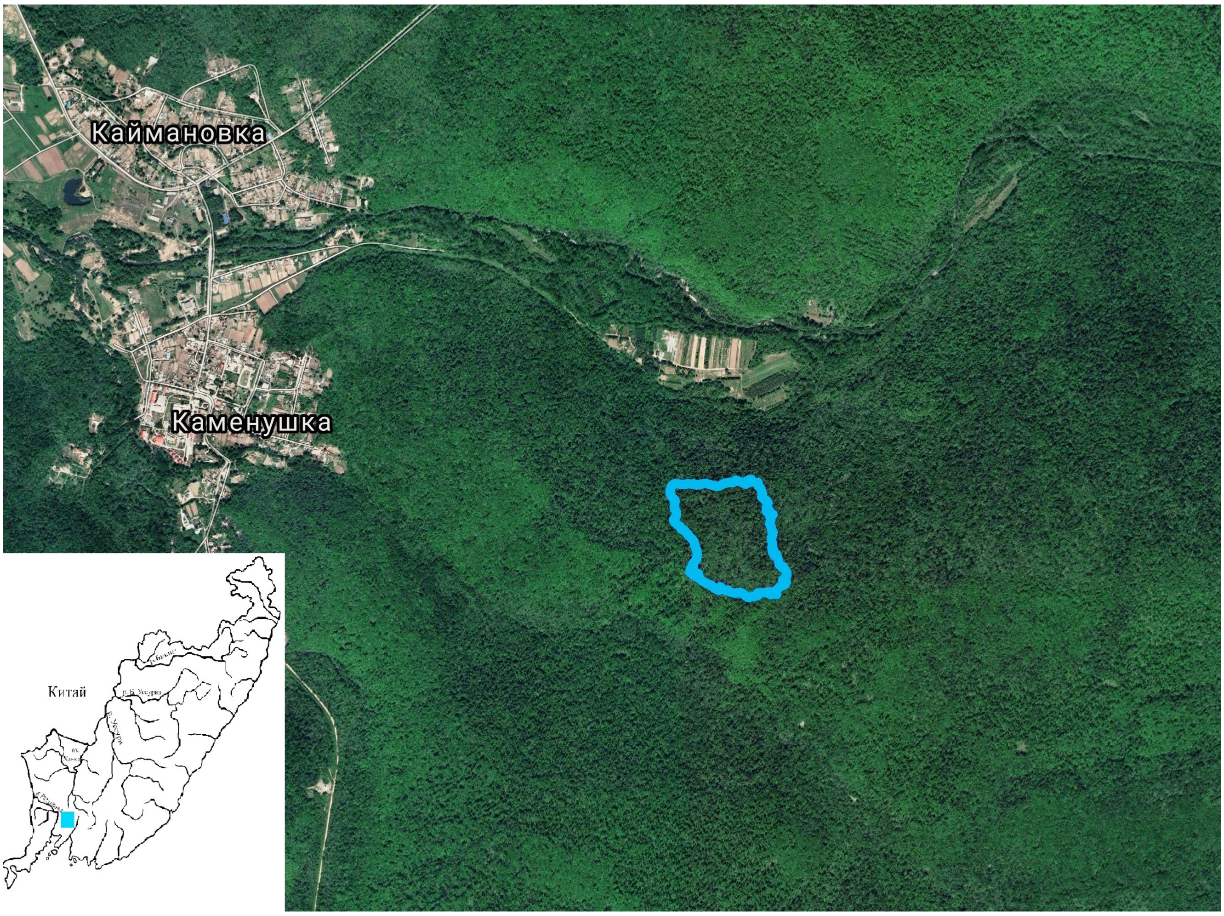

Fig. 1. Location of the sample plot. Surroundings of the village of Kamenushka, Ussuriysk urban district, Primorsky Region. The inset shows the research area

Рис. 1. Расположение пробной площади. Окрестности с. Каменушка, Уссурийский городской округ, Приморский край. На врезке показан район исследований

(Trautv.), *Quercus mongolica* Fisch. ex. Ledeb., *Phellodendron amurense* Rupr. The second story was represented by *Acer mono* Maxim., *A. mandshurica* Maxim., *Carpinus cordata* Blume, *Syringa amurensis* Rupr., *Padus maackii* Rupr., *Cerasus maximowiczii* (Rupr.). The relative stand density was 0.5–0.7. The abundant undergrowth consisted of *Philadelphus tenuifolius* Rupr. et Maxim., *Lonicera praeflorens* Batal., *L. chrysantha* Turcz. ex. Ledeb., *L. maackii* (Rupr.) Maxim., *Eleutherococcus senticosus* (Rupr. et Maxim.) Maxim., *Aralia elata* (Miq.) Seem., *Acer tegmentosum* (Maxim.) Maxim., *A. ukurunduense* Trautv. et C. A. Mey, *A. barbinerve* Maxim. The nonlayered vegetation was well developed, represented by *Schisandra chinensis* (Turcz.) Baill., *Actinidia arguta* (Siebold et Zucc.) and *A. kolomikta* (Rupr. et Maxim.) Maxim., *Vitis amurensis* Rupr. The herbaceous cover consisted of ferns and various grasses. The projective coverage was 70–80%. The proportion of *Ulmus laciniata* in the stand was 13%.

Materials and methods

According to the method developed by G. M. Elsky (1975), we set out 2 m wide sample stripes and counted trees with bark damaged by red deer within those stripes. Diameters of damaged tree trunks were measured at a height of 1.3 m (DBH) with a tree caliper. On large elms, we used a measuring tape to measure the area where the bark was removed. Trees “ringed” by deer (from which the bark was removed in a circle) were particularly noted. Additionally, the density of the undergrowth of *Ulmus laciniata* and the share of damaged stems were determined in 130 circular sample plots of 10 m^2 each according to the standard method (Martynov 1984; Ukazaniya po proektirovaniyu…. 1997). The assessment of the state of the undergrowth was carried out according to the method developed by A. S. Tikhonov (2011). The age of the damaged undergrowth was also determined by counting the annual rings on the cuttings (n = 17) and by testing age cores (n = 5) in large trees, as well as according to the diameter-age reference table (Koryakin 2010).

We also used some data from 1986 to 2021 that we obtained by participating in winter route surveys and monitoring of the Amur tiger within the Ussuriyskiy State Nature Reserve (Ussuriysk urban district and Shkotovsky district), as well as the Krasnoarmeysky, Nadezhdinsky and Mikhailovsky districts of Primorsky Region.

Results

Based on the resting places, the size and shape of the excrements we found, it is assumed that the group of *Cervus elaphus xanthopygus* that lived in this forest area did not exceed five individuals of different ages.

An assessment of *Ulmus laciniata* undergrowth condition within the sample plot showed that its density was 162 pcs./ha (corresponding to the “rare” prevalence category), of which 82 pcs./ha (50.5%) were damaged. The undergrowth was found both in single individuals and in groups, with a quite uneven distribution (occurrence 51%), medium height (1.2–1.5 m and medium quality.

Within the sample plot, we detected bark damage in 249 trees of *Ulmus laciniata*. Of these, 249 stems were young trees from 0.5 to 7.4 cm DBH (M = 3.75 ± 0.069, n = 249). The age of the damaged undergrowth determined by the annual rings on the cuts ranged from 6 to 38 years (M = 17.86 ± 3.996, n =1 7) (Table 1).

The damaged bark area in the undergrowth of *Ulmus laciniata* ranged from 0.01 to 0.45 m^2 (M =0.11 ± 0.096, n = 249).

In addition to undergrowth, mature trees of *Ulmus laciniata* with DBH from 24 to 56 cm (M = 40.2 ± 3.034, n = 10) were damaged within the sample plot. The age of the trees ranged from 67 to 179 years (M = 128 ± 9.8, n=10) (Table 2). The damaged bark area in mature *Ulmus laciniata* ranged from 0.14 to 2.20 m^2 (M = 1.05 ± 0.217, n = 10).

Table 1

Properties of damaged *Ulmus laciniata* undergrowth

Таблица 1

Характеристика поврежденного подроста ильма лопастного *Ulmus laciniata*

Middle of the diameter class (cm)	Diameter limits (cm)	Area of stripped bark (m^2)	Age (years)	n
1	0.5–1.4	0.01–0.04 (M = 0.02 ± 0.001)	≤6	27
2	1.5–2.4	0.02–0.12 (M = 0.05 ± 0.004)	≤10	54
3	2.5–3.4	0.01–0.45 (M = 0.08 ± 0.012)	≤13	60
4	3.5–4.4	0.02–0.29 (M = 0.12 ± 0.012)	≤15	48
5	4.5–5.4	0.04–0.18 (M = 0.10 ± 0.008)	≤20	36
6	5.5–6.4	0.09–0.34 (M = 0.18 ± 0.017)	≤23	24
7	6.5–7.4	0.18–0.38 (M = 0.25 ± 0.014)	≤38	9
Σ	249			

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Table 2

Properties of the damaged mature *Ulmus laciniata* trees

Таблица 2

Характеристика поврежденных взрослых деревьев ильма лопастного *Ulmus laciniata*

Middle of the diameter class (cm)	Diameter limits (cm)	Area of stripped bark (m^2)	Age (years)	n
24	22.1–26	0.14	67	1
28	26.1–30	0.20	101	1
32	30.1–34	0.19	115	1
36	34.1–38	0.12	118	1
40	38.1–42	0.90–1.44	126	2
44	42.1–46	2.20	140	1
48	46–50	0.42–0.63	153	2
52	50.1–54	0	0	0
56	54.1–58	0.28	179	1
Σ	10			

In young elms, deer used their incisors to hook bark in the lower part of the trunk and pulled it towards themselves, tearing off long narrow strips. In large trees, they scraped off the bark, eating around the tree in a more or less rectangular area. The lower boundary of the scrape marks was at a height from 0.05 to 1.50 m from the ground, with the upper edge from 0.3 m to 4.0 m (Fig. 2).

In 53 young elms the bark was eaten around the tree. Subsequently when visiting the sample plot at the end of summer, we noted the death (drying out) of damaged elms (Fig. 3).

Discussion

Stripping bark of *Ulmus laciniata* is prevalent in the feeding behaviour of *Cervus elaphus xanthopygus* in the Primorsky Region. For instance, L. G. Kaplanov (1948) noted this phenomenon in the Sikhote-Alinsky State Natural Biosphere Reserve and V. V. Gaponov (1991) recorded it in the basins of the Pavlovka, Zhuravlevka and Otkosnaya rivers in the Chuguevsky municipal district. Across many years, we have repeatedly encountered characteristic damage of *Ulmus laciniata* by *Cervus elaphus xanthopygus* within the Ussuriysky State Nature Reserve, and this feeding behaviour was confirmed by data from camera traps installed in the animals' winter stations (Fig. 4).

We also noted single young trees of *Ulmus laciniata* with stripped bark in "The Udege Legend" National Park in the valley of the Bolshaya Ussurka river near the mouth of the Armu river in the Krasnoarmeysky district (N 45°45′52″, E 135°28′35″) in June 2021 (Fig. 5). In the same summer, characteristic *Ulmus laciniata* undergrowth damage was found in the upper reaches of the Perevoznaya River on the north-eastern slope of the Dlinnaya Mountain in the Nadezhdinsky district (N 43°32′88″; E 132°05′99″).

According to Gaponov (2006: 18), *Ulmus laciniata* "is the only species whose bark is damaged by Manchurian red deer". However, Kaplanov (1948) noted that these ungulates also eat the bark of lime trees, aspens, Maak cherry, aralia, chosenia, willows, ash and even larch. The same is noted by B. A. Mikhailovsky (1975), although he observed *Cervus elaphus xanthopygos* feeding on branches and bark of *Ulmus japonica* (= *U. propinqua*) (Rehder) Sarg. in Middle Sikhote-Aline and did not observe deer consuming parts of *Ulmus laciniata*. It is most likely that in different parts of its range *Cervus elaphus xanthopygus* can consume the bark of different species of trees and shrubs.

Fig. 2. Bark damage in large *Ulmus laciniata* after bark stripping by *Cervus elaphus xanthopygus*. Sample plot. 3.05.2021. Authors' photo

Рис. 2. Характер повреждений коры у крупных ильмов лопастных после кормежки изюбрей. Пробная площадь. 3 мая 2021 г. Фото авторов

Nevertheless, in the sample plot studied by us, the deer did not eat the bark of other tree species, except for *Ulmus laciniata*, despite the presence of its favourite forage plants in the stand: *Fraxinus mandshurica* Rupr., *Tilia* sp., *Acer tegmentosum* Maxim., *A. mono* Maxim., *Micromeles alnifolia* (Siebold et Zucc.) Koehne, etc. It is interesting to note that we found a large ash tree, broken by the wind. Its small branches and bark from main branches were eaten by red deer, but the bark on the trunk remained undamaged, just as the bark of standing ash trees.

Notably, both *Ulmus laciniata* and *Ulmus japonica* are also part of the diet of another Far Eastern deer, sika deer *Cervus nippon* Temminck. This ungulate was recorded eating elm bark in the Lazovsky State Nature Reserve (Makovkin 1999). There, bark stripping was so severe that the elms began to dry out and fall out of the stand. Elm bark is severely damaged by sika deer in the forests of the islands of Hokkaido and Honshu (Japan) (Higa et al. 2020; Kaji et al. 2010; Masuko et al. 2011;Uno et al. 2009; Yokoyama et al. 2000). Studies in the Ooyamazawa Valley Forest have shown a clear food selectivity of sika deer in relation to the bark of *Ulmus laciniata* (Higa at al. 2020).

Other elm species are also part of red deer preferred diet. For instance, *Ulmus pumila* L. is an important component of the winter diet of the Alashan red deer *Cervus elaphus alxaicus* Bobrinskii et Flerov in the Helan Mountains in North-Central China (Cui et al. 2007; Zhang et al. 2013). In addition to that, white-tailed deer *Odocoileus virginianus* Zimmermann was observed eating the bark of the slippery elm *U. rubra* Muhl in West Virginia

Fig. 3. Bark damage in young *Ulmus laciniata* after bark stripping by *Cervus elaphus xanthopygus*. Sample plot. 3.05.2021. Authors' photo

Рис. 3. Характер повреждений коры у молодых ильмов лопастных после кормежки изюбрей. Пробная площадь. 3 мая 2021 г. Фото авторов

(USA), but this phenomenon had a very limited distribution over an area of only 240 hectares (Michael 1987).

We have identified interesting geographical differences in the preferences for consuming the bark of different tree species between the European subspecies of red deer and Manchurian red deer. As we can see, elm bark is the preferred early spring fodder for Manchurian red deer in the Far East. However, we have not been able to find notes of deer feeding on the bark of European elm species in the literature discussing bark stripping by red deer in Europe. At least 21 species of trees are known to be debarked by the European red deer (Dinesman 1959; 1961; Gill 1992a; Kaznevsky 1959; Mitchell et al. 1977; Verheyden et al. 2006).

Despite the fact that three species of elms — *Ulmus laevis* Pall., *U. glabra* Huds. and *U. minor* Mill. (Caudullo, de Rigo 2016; Vasiliev 1986) — are common in Europe, there is no mention of bark stripping of European elms by European red deer in prior research. These three species are quite widespread throughout Europe from Spain to the European part of Russia, and are a common component of mixed forest stands along river valleys (Caudullo, de Rigo 2016; Vasiliev 1986), meaning that red deer in Europe do have access to this food resource. Only N. N. Yevtushevsky and A. M. Mamenko (2013) (out of all sources available to us) mention European red deer eating *U. minor* and *U. laevis* in the Middle Dnieper region and the Carpathians (Ukraine). There is a mention of sika deer eating the same species of elm in the Khopersky State Nature Reserve (Voronezh region, Russia) (Aghababyan 1951). However, we suppose that these articles refer to browsing shoots and not bark stripping.

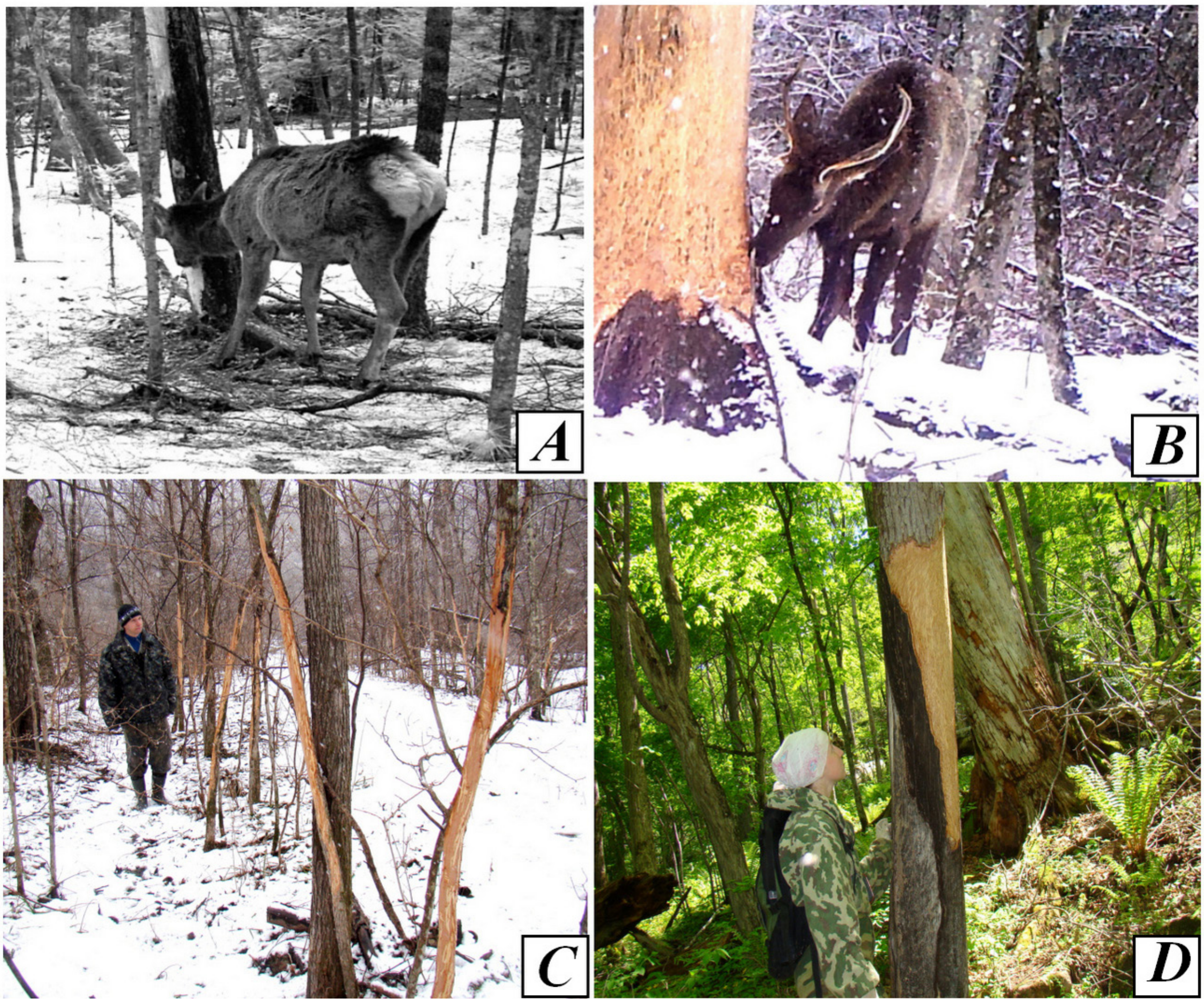

Fig. 4. *A* — Young *Cervus elaphus xanthopygus* feeding on the bark of *Ulmus laciniata*. Ussuriysky Nature Reserve. Suvorovskoye forestry. Shkotovsky district. 18.04.2010. Leaf River camera trap; *B* — A young male *Cervus elaphus xanthopygus* eating cambium from a large *Ulmus laciniata*. Ussuriysky Nature Reserve. Komarovskoye forestry. Ussuriysk urban district. 21.03.2021. Bushnell camera trap; *C* — A researcher examines a group of young *Ulmus laciniata* debarked by *Cervus elaphus xanthopygus*. Ussuriysky Nature Reserve. Suvorovskoye forestry. Shkotovsky district. 13.04.2010. Photo by M. Maslov; *D* — A researcher examines *Ulmus laciniata*, debarked by *Cervus elaphus xanthopygus* at a different time. Ussuriysky Nature Reserve. Komarovskoye forestry. Ussuriysk urban district. 27.05.2010. Photo by M. Maslov

Рис. 4. *A* — сеголеток изюбря, питающийся корой ильма лопастного. Уссурийский заповедник. Суворовское лесничество. Шкотовский район. 18 апреля 2010 г. Фотоловушка Leaf River; *B* — молодой самец изюбря объедает камбий с крупного ильма лопастного. Уссурийский заповедник. Комаровское лесничество. Уссурийский городской округ. 21 марта 2021 г. Фотоловушка Bushnell; *C* — научный сотрудник осматривает группу молодых ильмов лопастных, с которых изюбри объели кору. Уссурийский заповедник. Суворовское лесничество. Шкотовский район. 13 апреля 2010 г. Фото М. Маслова; *D* — научный сотрудник осматривает ильм лопастной, на котором наблюдаются следы обгрызания изюбрем коры разной давности. Уссурийский заповедник. Комаровское лесничество. Уссурийский городской округ. 27 мая 2010 г. Фото М. Маслова

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Fig. 5. Young *Ulmus laciniata* debarked by *Cervus elaphus xanthopygos*. "The Udege Legend" National Park. Krasnoarmeysky district. 2.06.2021. Photo by D. Belyaev

Рис. 5. Молодой ильм лопастной с объеденной изюбрем корой. Национальный парк «Удэгейская легенда». Красноармейский район. 2 июня 2021 г. Фото Д. Беляева

Apparently, red deer is generally characterised by geographical variability in food preferences, even within the same subspecies. Thus, the bark of the white fir is preferred by deer in the Polish part of Białoweza Primeval Forest and the Carpathians (Gębczyńska 1980; Jamrozy 1980), but at the same time it is among the least preferred tree species in Germany (Gill 1992a) and Austria (Vospernik 2006). European beech is rarely eaten in the Polish Carpathians (Jamrozy 1980) or in Austria (Vospernik 2006), but its bark is readily eaten by red deer in north-eastern France and Serbia (Gačić et al. 2012; Saint-Andrieux et al. 2009; Verheyden et al. 2006). The bark of the European spruce is scarcely eaten by deer in the Belarusian part of Białoweza Primeval Forest (Sablina 1959), whereas in other parts of Europe it is one of their favourite fodders (Gill 1992a; Verheyden et al. 2006). In Austria, red deer prefer the bark of European spruce and common ash, but do not like the bark of Scots pine and poplar, as in other European countries (Vospernik 2006). The bark of the European hornbeam *Carpinus betulus* Grossh. is readily eaten by deer in Serbia and Slovakia (Gačić et al. 2012; Nevřelová, Ružičková 2015), but is not eaten in Belarus (Sablina 1959). It is interesting to note that in our sample plot *Carpinus cordata* was one of the main second story species of the stand, but none of the trees of this species had its bark stripped by red deer.

Bark stripping is unusual for the North American wapiti *Cervus elaphus roosevelti* Merriam and *C. e. nelsoni* (Erxleben) (Gill 1992a). In the USA and Canada, bark damage was only noted in the quaking aspen *Populus tremuloides* Michx. and in willows *Salix* sp., mainly in the places of wapiti concentration in winter, for example, near feeding spots (Black 1994; Burleigh et al. 2014; De Byle 1985; Dolbeer et al. 1994).

It should be noted that red deer only engage in bark stripping for a fairly short period of time; however, the data differ both between different regions and between tree species. Often, the deer start eating the bark in spring and continue to do so throughout summer, however, bark stripping in summer is mostly confined to European beech, as its bark is easier to detach from the trunk in summer (Gačić et al. 2012; Kurek et al. 2019; Saint-Andrieux et al. 2009; Verheyden et al. 2006). The bark of other tree species is usually eaten by deer in autumn and winter (Gębczyńska 1980; Gill 1992a; Nevřelová, Ružičková 2015; Sablina 1959). In the south of the Far East, red deer start eating tree bark in late autumn (Bromley, Kucherenko 1983; Gaponov 2006; Kaplanov 1948). In winter, they stop bark stripping, because at this time the bark freezes, and it is quite difficult to tear it from the trunk. In addition to that, it is likely that *Cervus elaphus xanthopygus* ceases to eat bark in winter due to the bark's poorer thermal properties, given the amount of frozen water in it (Kaplanov 1948; Mikhailovsky 1975). After that, bark feeding resumes in spring, when the bark thaws in the sun, and continues until the appearance of green fodder (Bromley, Kucherenko 1983; Kaplanov 1948). In our case, it is clear that the deer debarked elms in late winter and early spring. This is evidenced by the light colour of the exposed wood, clearly visible from afar. Over time, the debarked surfaces darkened, and by summer it became difficult to identify the damaged trunks. This is also evidenced by the large number of winter excrement of *Cervus elaphus xanthopygus* found on the sample plot. When visiting this area of the forest in the summer, we did not find any fresh bark damage.

Tree size and age also affect the preference of red deer for them (Gill 1992a, b). As a rule, deer prefer to peel bark from small trees, because it is thinner and less coarse in young trees. As a rule, the bark is stripped from trees with DBH of 4-20 cm at the age of 20 years. Subsequently, debarking intensity decreases with increasing age of the tree and thickness and roughness of the bark (Bromley, Kucherenko 1983; Gačić et al. 2012; Gill 1992a; Kurek et al. 2019; Mitchell et al. 1977; Nevřelová, Ružičková 2015; Szukiel 1981; Vospernik 2006). The same trend was observed for sika deer in Japan (Akashi, Nakashizuka 1999). However, older trees with a large trunk diameter are not immune from bark stripping (Gill 1992a; Kaplanov 1948).

Our data obtained in Primorsky Region confirm these observations. Manchurian red deer mainly damage undergrowth and young trees with DBH 0.5–7.4 cm ($M = 3.75 \pm 0.069$) up to 40 years old. The damaged bark area in *Ulmus laciniata* undergrowth was 0.01–0.45 m^2 ($M = 0.11 \pm 0.096$ m^2, $n = 249$). At the same time, deer ate more bark from large trees by area on average when converted to one tree. The area of damaged bark in adult *Ulmus laciniata* was 0.14–2.20 m^2 ($M = 1.05 \pm 0.217$ m^2; $n = 10$). However, this may be only a consequence of a small proportion of *Ulmus laciniata* in the tree stand: it was easier for the deer to find more common young trees than to find large trunks.

There were very few undamaged large trees in the area — no more than three trees. Kaplanov (1948) also noted that *Cervus elaphus xanthopygus* often peel bark from large elm

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trees with a trunk diameter of up to 50 cm. The above data is not in line with the data of Gaponov (1991: 45; 2006: 18), who stated "that the Manchurian red deer seems to pity the undergrowth of elm and ash tree, allowing it to grow". It is possible that the underestimation of the influence of *Cervus elaphus xanthopygus* on undergrowth in this case is associated with local deer food preferences. In addition to this, the strips of eaten bark on large trees in the forest are much more noticeable than on the undergrowth, creating the illusion of preference for trees with large diameters.

Further observations are required for the definitive analysis of the nature of the food behaviour of the *Cervus elaphus xanthopygus* and its effect on the undergrowth and large trees of *Ulmus laciniata* in the south of the Russian Far East.

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