Musk deer *Moschus moschiferus* nutrition in the Tukuringra Mountain Range, Russian Far East, during the snow season

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ABSTRACT. The study of musk deer nutrition was conducted during the 2010-2013 snow seasons on the Tukuringra Mountain Range, Russian Far East. Gastric content analysis and detailed tracking was conducted as well. Sixty four kinds of forage preferred by musk deer were recorded. Data on forage composition in different habitats were received. Peculiarities of the musk deer nutrition on the Tukuringra Mountain Range were revealed.

KEY WORDS: nutrition, musk deer, lichens, shrub, Tukuringra Mountain Range, forage.

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Питание кабарги *Moschus moschiferus* на хребте Тукурингра, Дальний Восток, в снежный период года

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РЕЗЮМЕ: В период 2010–2013 гг. на хребте Тукурингра (Дальний Восток России) были проведены исследования питания кабарги в снежный период. Осуществлен анализ содержимого желудков и ряд детальных троплений. Зафиксировано 64 вида корма, предпочитаемые кабаргой. Получены данные о составе кормов в различных местообитаниях. Выделены особенности питания кабарги на хребте Тукурингра.

КЛЮЧЕВЫЕ СЛОВА: питание, кабарга, лишайники, кустарники, хребет Тукурингра, вид корма.

Introduction

Musk deer (*Ìoschus moschiferus* Linnaeus, 1758) is a representative of small ungulates. These animals live in mountain taiga ecosystems of Asia. For a long time ecologists knew that nutrition of animals and their food chains depend mainly on biocenoses. There is hardly any ecological report not touching upon these important issues (Novikov, 2009). Currently there are data on forage composition of musk deer from the Eastern Sayan Mountains, Transbaikalia, Sakha Republic, and Russian Far East (Ustinov, 1969; Prikhod'ko, 2003; Zaitsev, 2006; Krivoshapkin, 2008).

On the Tukuringra Mountain Range (Russian Far East) a musk deer is considered to be common species. Musk deer inhabit different areas of the mountain range because this area is situated on the border the units of phytogeographical zoning (Gubanov, 1981). Therefore, forage stations of this species can consist of different eatable items. Currently nutrition of musk deer during snow seasons has not been completely studied (Domanov, 2012a). Therefore, it is important to study this aspect of the species ecology.

Material and methods

Material has been collected during the period of 2010–2012 on Tukuringra Mountain Range, which is located in Amur region (Russian Far East) and is a part of the Tukuringra and Dzhagdy Ecoregion. The main relief categories of the Eastern part of the mountain range are sharply dissected mid-mountains and slightly dissected low mountains (Gubanov, 1981). The relief of the Eastern part of this mountain range is represented by slightly dissected mid-mountains. The altitudes vary from 500 to 1604 m above sea level. The rivers of the territory under discussion belong to Amur and Zeya basins. There are spruce and *Chosenia* forests, larch forests with some poplars (*Populus maximowiczii*) there kinds of alder trees (*Alnus fruticosa*, *A. hirsuta*, *A. sibirica*) and red dogwood trees (*Swida alba*) in the undergrowth, depauperated larch forests (*Larix gmelini*) with reindeer moss and dwarf birch trees (*Betula middendorffii*) grow in the river valleys. Larch is frequent on the slopes, while spruce (*Picea ajanensis*) and birch trees (*Betula platyphylla*) are less frequent. Open larch forests and mountain pine (*Pinus pumila*) are widely spread in the watershed. Large areas of open reindeer moss and larch forests grow on the gentle slopes of the central and Western parts of the mountain range, along with mountain pines and dwarf birch trees as an undergrowth. These areas are inhabited by musk deer, even though the conditions are not very favorable for them here (Domanov, 2012b).

Methods applied by various authors in different regions were used in the process of studying nutrition:
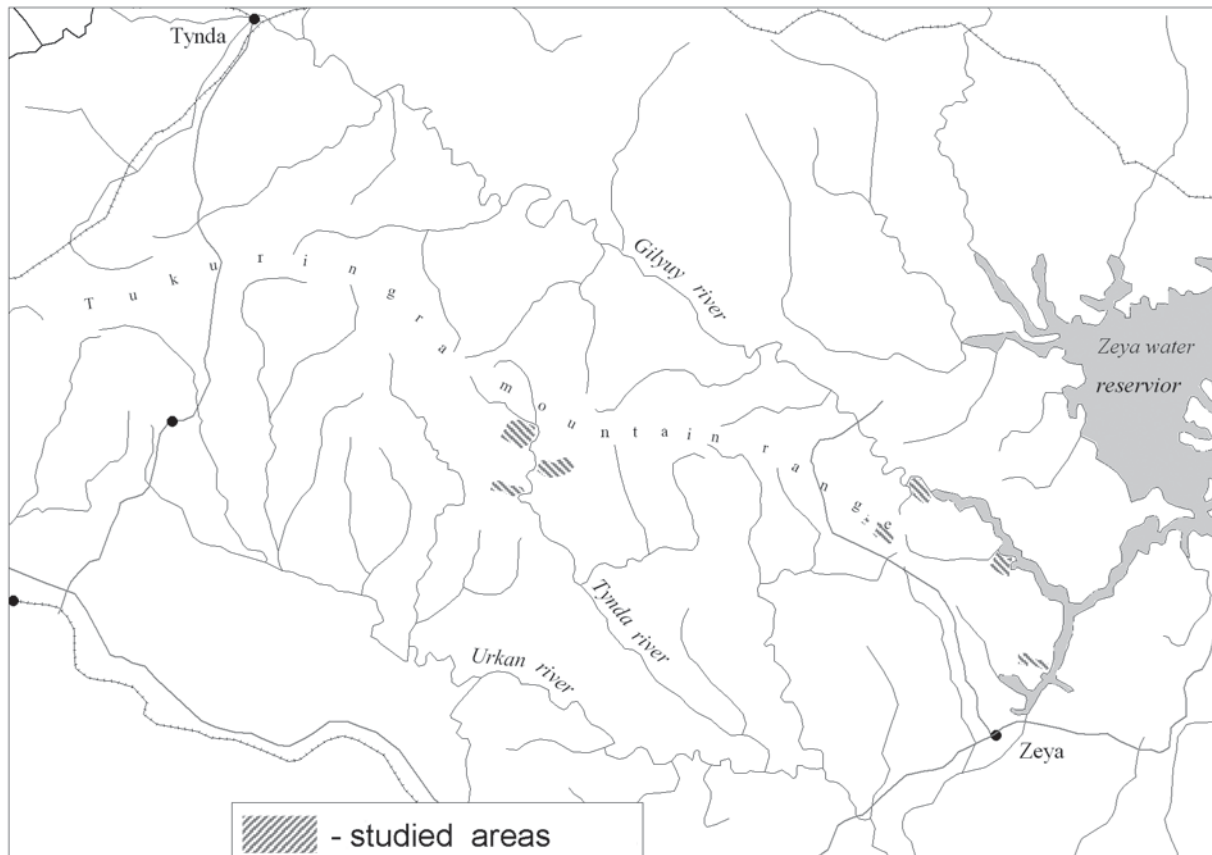
Figure. The areas chosen to be studied for musk deer nutrition using the method of tracking.

forage stations were inspected, tracked in details (daily and partially), grazers were observed, and gastric contents was analysed (Bannikov *et al.*, 1978; Argunov, 2009; Mirutenko *et al.*, 2009; Maslov, 2011). These methods were practiced in the eastern part of the Tukuringra Mountain Range (headstream of the Tynda River) on the hunting territories, and also in the eastern part of the same mountain range on the territory of the Zeya Nature Reserve.

Musk deer forage stations were investigated, animal behavior was observed, and forage trails were studied, taking into account plant, fungus, and lichen species.

Tracking was performed on the southern and northern macroslopes of the Tukuringra Mountain Range (Fig. 1). There were 26 full days and 18 partial days of tracking, including two multiple day tracking. Total tracking distance was 43.4 km. The distance of tracking was measured with the GPS and counted by the steps (Mirutenko *et al.*, 2009). We registered types of forage. In total 2444 food remains debris were recorded. The specific weight of forage items was calculated, as well as their frequency. According to the daily tracking data, the number of different kinds of plants eaten by the animals was determined for each day. All unknown plants were collected for the further identification.

The average snow depth was 0.19–1 m on the tracking areas during the whole period of study. Most types

of musk deer habitats of the Tukuringra Mountain Range were studied (Tab. 1).

The content of rumen (the first and the biggest part of four-chambered stomachs in ruminant artiodactyls) was also analyzing. It is helpful in evaluating of the weighting of different food items in the feed ration of a ruminant animal in a particular period (Prikhod'ko, 2003; Abaturov, 2005).

Other authors used this method to study musk deer nutrition in different parts of their natural habitat (Ustinov, 1969; Bannikov *et al.*, 1978; Zheng & Pi, 1979; Prikhod'ko, 1992; Liu & Sheng, 2000). We studied 16 musk deer stomachs during the 2012–2013 winter period on the hunting territories of the Tyndinskiy Promkhoz and the Amuroblpotrebsoyuz. A few stomachs were received from local hunters (*n*=10), while others were found in dead musk deer specimens killed by predators (*n*=6). Then is used sampling methodology of the stomach (Argunov, 2009; Mosolov & Fil, 2010). One sample of 250 ml is taken from each of the stomach.

The samples were weighed on the electronic scales with a precision of 0.01 g. Specific weight of the samples was measured as well. All samples were taken as 100%. Some fragments of lichens, shrubs, subshrubs, fungi, and woody plants were singled out during the analysis. The frequency of different forage types occurrence has also been determined (Tabs. 2, 3). Poorly

Table 1. Musk deer tracking in the Tukuringra Mountain Range.

Type of habitat (river basin)	Number of trackings			Total, km
	Partial	One day	Multiple days	
Open larch forest (Gilyuy River, Shatamu River)	3	2	0	4.1
Dense ripe larch forest with spruces on the second layer (Kamenistaya River, Bolshaya Erakingra River)	3	1	0	5.8
Dense ripe larch forest with birch trees and rhododendrons (Gilyui River, Motovaya River, Sivak River)	5	12	1 (4 days)	22.5
Black birch tree forest with Mongolian oaks and aspens (Razvedochnaya River, Sukhaya River)	3	2	0	3.9
Sub-barrens Yezo spruce forest (headstream of Shatamu River, headstreams of Bannaya and Kamenushka River)	1	2	0	2.6
Burnt wood 3–10 years old (Baranovskaya River, Razvedochnaya River, Bolshaya Tynda River)	3	7	1 (5 days)	4.5
Total trackings	18	26	2	43.4

Table 2. Frequency of forage occurrence during snow seasons in the Tukuringra Mountain Range according to the rumen analysis data.

Type of forage		Frequency of occurrence, %	Specific weight, % (limits)
Lichen	*Usnea* sp.	31.25	5.23 (2.00–33.70)
	Evernia sp.	68.75	24.92 (1.00–85.50)
	Bryoria sp.	25.00	2.23 (2.20–23.25)
	Cladonia sp.	56.25	22.81 (5.10–82.10)
Herbaceous	Small reed	18.75	1.60 (0.20–24.00)
	Carex sp.	43.75	
	Doelingeria scabra	6.25	
	Fern	12.50	
Shrubs and subshrubs	Bushy alder tree	50.00	18.28 (0.40–45.50)
	Middendorff birch tree	12.50	
	Dahurian rhododendron	18.75	
	Prickly wild rose	6.25	
	Red bilberry	31.25	
Arboreal	Dahurian larch buds	6.25	21.74 (1.00–48.52)
	Dahurian larch needles	68.75	
	Ayan spruce needles	12.50	
	Willow leaves	31.25	
	Wood, tree branches, Japanese white birch leaves	56.25	
Mosses	Frondiferous	12.50	1.72 (0.10–2.73)
	Sphagnum	25.00	
Fungi	Arboreous	12.50	1.20 (3.50–15.64)
Small mammals	Laxmann's shrew	6.25	0.27 (0.10–2.00)
	Grey red-backed vole	25.00	

chopped forage fragments, such as leave and stem parts, lichen frond parts, seeds helped to identify the kinds of plants.

Results and discussion

In total 192 species of vascular plants, fungi, lichens were found in the diet of Siberian musk deer. They belong to 55 families (Prikhod'ko, 1992). The composition of forage strongly depends on the natural habitat of musk deer (Khumes, 2004). Thus, they eat more than 34 species in the Sakha Republic (Egorov, 1965). Forty nine species of plants consumed by musk deer were found in Altai region (Shaposhnikov, 1965). More than 19 species were found in Primorye region (Salmin, 1972).

Table 3. Frequency of occurrence and correlation of different forage types in musk deer nutrition, according to tracking results in the Tukuringra Mountain Range.

Type of forage		Frequency of occurrence, %	Correlation, % (limits)
Fungi	Arboreal	29.41	1.16 (0.39–3.39)
	Pileate	17.64	1.02 (0.30–2.17)
Lichens	Arboreal	94.10	28.23 (2.29–53.68)
	Terrestrial	35.29	15.92 (16.64–46.76)
Mosses		58.82	8.58 (0.26–23.15)
Herbaceous		58.82	0.97 (0.37–2.24)
Shrubs and subshrubs		94.10	34.36 (1.30–88.54)
Arboreal		70.58	3.10 (0.96–11.11)
Small mammals		2.38	0.04 (0–0.19)

On the Tukuringra Mountain Range our study found 64 species of forage items consumed by musk deer during the snow season, including 41 species of vascular plants, 13 species of lichens, four species of fungi, and two species of mammals. In average, the animals consumed 10 species of forage per day. The ration of the animals consisted of a particular number of species in each type of habitat. The greatest variety of forage species was discovered during tracking in black birch forests with oaks on steep slopes and in larch forest with birch trees on gentle slopes, and in the valley. In these kinds of habitat musk deer had 17–18 species of forage per day. The poorest variety of species was discovered in sub-barrens spruce forests with some larches and in ripe larch forests with some spruces. In these areas the animals eat 5–6 species per day. The composition of forage species depended on the depths of snow cover.

List of forage components occur in musk deer diet during snow seasons

Fungi
Family Polyporaceae
1. Birch polypore (*Piptoporus betulinus*)
Family Poriaceae
2. Violet-toothed polypore (*Trichaptum biforme*)
Family Hymenochaetales
Pellinus sp.
3. Family Russulaceae
4. *Russula* sp.

Lichens
Family Parmeliaceae
5. *Parmotrema chinensis*
6. *Parmelia saxatilis*
7. *Hypogymnia enteromorpha*
8. *Vulpicida pinastri*
9. *Platismatia glauca*
10. *Bryoria implexa*
11. *Cetraria chrysantha*
12. *Cetraria laevigata*

13. *Usnea longissima*
14. *Evernia mesomorpha*
Family Cladoniaceae
15. *Cladonia coccifera*
16. *Cladonia rangiferina*
17. *Cladonia stellaris*
Family Stereocaulaceae
18. *Stereocaulon alpinum*

Bryophytes
Class Bryopsida
19. unknown species
Family Sphagnaceae
20. *Sphagnum* sp.

Vascular plants
Family Fabaceae
21. *Vicia* sp.
22. Bicolor lespedeza (*Lespedeca bicolor*)
Family Asteraceae
23. *Saussurea neoserrata*
24. Wormwood, 2 species (*Artemisia* spp.)
25. *Doelingeria scabra*
26. Narrowleaf hawksbeard (*Crepis tectorum*)
Family Plantaginaceae
27. Siberian veronicastrum (*Veronicastrum sibiricum*)
Family Cyperaceae
28. Cotton grass (*Eriophorum* sp.)
29. *Carex* sp.
Family Rosaceae
30. Red raspberry (*Rubus idaeus*)
31. Bird cherry (*Prunus padus*)
32. False Spiraea (*Sorbaria sorbifolia*)
33. Prickly wild rose (*Rosa acicularis*)
34. Ussurian meadowsweet (*Spiraea ussuriensis*)
Family Oleaceae
35. Amur lilac (*Syringa amurensis*)
Family Betulaceae
36. Erman's birch (*Betula ermanii*)
37. Middendorff birch (*Betula middendorffii*)
38. Japanese white birch (*Betula platyphylla*)
39. Alder shrub forest (*Duschekia fruticosa*)

Family Caprifoliaceae
40. Blue-berried honeysuckle (*Lonicera edulis*)
41. *Lonicera chrysantha*
Family Campanulaceae
42. Ladybell (*Adenophora* sp.)
Family Poaceae
43. Small reed (*Calamagrostis* sp.)
Family Ericaceae
44. Marsh Labrador tea (*Ledum palustre*)
45. Dahurian rhododendron (*Rhododendron dauricum*)
Family Vacciniaceae
46. Red bilberry (*Vaccinium vitisidaea*)
47. Cranberry (*Oxycoccus microcarpus*)
Family Pyrolaceae
48. Bog wintergreen (*Pyrola asarifolia*)
Family Salicaceae
49. Aspen (*Populus tremula*)
50. Willow (*Salix* sp.)
51. *Chosenia arbutifolia*
Family Cornaceae
52. Siberian dogwood (*Cornus alba*)
Family Onagraceae
53. Fireweed (*Chamerion angustifolium*)
Family Grossulariaceae
54. Sweet currant (*Ribes fragrans*)
55. *Ribes procumbens* Pall.
56. Dikusha currant (*Ribes dikusha*)
Family Pinaceae
57. Siberian spruce (*Picea obovata*)
58. Ayan spruce (*P. ajanensis*)
59. Mountain pine (*Pinus pumila*)
60. Dahurian larch (*Larix gmelinii*)
Family Woodsiaceae
61. *Pseudocystopteris spinulosa*
Family Cystopteridaceae
62. Brittle bladder fern (*Cystopteris fragilis*)

Mammals
Family Soricidae
63. Laxmann's shrew (*Sorex caecutiens*)
Family Cricetidae
64. Grey red-backed vole (*Clethrionomys rufocanus*)

Analysis of the rumen contents showed that shrub lichens make the biggest part in the nutrition structure of musk deer in almost all types of habitat. Detailed tracking also showed high specific weight of this forage. Its occurrence frequency is also high (Tabs 2 and 3).

Lichens eaten by musk deer were from 11 genera of three families. The most important species for these animals were bushy lichens (*Evernia mesomorpha*). According to the rumen content analysis, its specific weight is 24.92% (limits 1.00–85.5%), according to tracking data, it is 23.18% (limits 1.37–76.60%).

The most frequently consumed terrestrial lichens are *Cladonia coccifera, C. rangiferina,* and *C. stellaris.* The share of these three kinds made 22.81% (limits 5.10–82.10%) among other kinds of forage in rumen

samples, according to tracking data they made 11.11% (limits 1.37–43.84%). Specific weight and frequency of occurrence in the lichen rumens (*Usnea longissima*) was insufficient — 5.23% (limits 2.00–33.70%). This species has been also found once during the tracking — 4.45% (limits 1.37–8.22). It is related to the local distribution of this kind of lichen on the Tukuringra Mountain Range (some valley areas, notches, northern exposure slopes), and also to the small amount of phytomass available.

Undoubtedly, musk deer were attracted by recently fallen trees covered with the *Usnea* lichen, but tracking showed that the animals rarely tried to look for this species intentionally either on the snow cover or on the tree branches.

Lichen share and species in the nutrition structure depended on the type of habitat (Tab. 4). The highest specific weight of lichen forage in the musk deer nutrition structure is found in open larch forests. In these areas their choice of lichen species depended on how thick and dense the snow cover was because if the snow was deep and the ice over it was dense, the musk deer had no access to the terrestrial species. In ripe larch forests with some birch trees or some spruces, the animals often eat arboreal and terrestrial species of lichens from the Parmeliaceae and Cladoniaceae families. Musk deer did not eat any lichens in burnt woods and black birch forest. In general, the average specific weight of the lichen forage in musk deer ration on the Tukuringra Mountain Range is comparable to the results of nutrition studies on other mountain ranges (Prikhod'ko, 2003), but the species composition of lichens is specific.

Shrubs and subshrubs are represented by 10 families, including 19 species, among which the most important ones are the representatives of the Ericaceae and Vacciniaceae families. Specific weight of these kinds of forage is also rather high. According to multiple day tracking data, Dahurian rhododendron contributes the largest share to the nutrition structure (72.97%, limits 43.65–94.04%) in both burnt larch forests and black birch forests. As rhododendron is easily accessible, it is consumed by musk deer during winter periods with both big and small amounts of snow. Musk deer preferred red bilberry leaves and stems in sub-barrens spruce forests and in ripe larch forests with some spruces on the second layer, if the snow cover was not so thick. Specific weight of these areas was 20.23% (limits 7.6–27.3%).

Bryophytes are represented by two species of two classes: sphagnum and frondiferous. Tracking results showed that the musk deer preferred *Sphagnum* mosses. Musk deer had this kind frequently in sub-barrens spruce forests and ripe larch forests with some spruces, where their share reached 11.67% (limits 4.26–24.32). In other kinds of habitat the bryophyte was rare in both food debris and rumen.

Among arboreal kinds of forage there are five families, including 11 species, among which four belong to

Table 4. Rate of lichens among other types of forage in different types of musk deer habitats in the Tukuringra Mountain Range, according to the tracking data.

Type of habitat	Family Parmeliaceae	Family Cladoniaceae	Family Stereocaulaceae
	Specific weight, %		
Open larch forest	27.40	48.66	1.37
Ripe larch forest with some birch trees	30.79	19.35	0.00
Ripe larch forest with some spruces	47.99	0.00	0.00
Black birch tree forest with oaks	2.02	0.00	0.00
Burnt wood	10.40	0.00	1.37
Sub-barrens spruce forest	37.96	0.00	0.00

coniferous and seven to larch trees. Animals ate pieces of rotten wood, bark, buds, needles, branches, and dry leaves that they found on parts of branches and soil surface. Share of this kind of forage is small (Tabs 2, 3). However, frequency of occurrence of some pieces (e.g. Dahurian larch needles) is rather sufficient, according to rumen analysis data. Musk deer consumed pieces of arboreal plants, while consuming other kinds of forage (lichens, fungi, subshrubs).

Herbaceous plants eaten by musk deer are represented by eight families, including 11 species. Specific weight of this kind of forage is not high. Frequency of occurrence of some plant species like *Carex* is rather high. The animals often found herbaceous forage on southern exposure slopes with rocky parts and in the valleys. The greatest variety of this kind of forage was found among food debris in black birch forest with oaks.

Fungi were represented by four species of four different families. The results of this study showed that the highest specific weight of all fungi had birch polypore. Trackings and observations showed that musk deer preferred this species frequently in burnt woods of 5–15 years old. After the fire some Japanese white birch trees died and formed large obstructions. These areas were favorable for this kind of fungus. Carefully going through these birch obstructions, the musk deer were finding arboreal fungi, spending two-three minutes near each carposome.

Pileate fungi of *Russila* sp. were found in ripe larch forest with some spruces on the second layer and in the undergrowth. In some cases musk deer tried to search for these fungi intentionally. Sometimes musk deer would find dry pileate fungi that were 10–15 m away and would make a sharp turn from the basic travel trajectory to the food item. Such cases were observed three times. In total 8 food debris of pileate fungi were found during trackings.

There was a grey red-backed vole found during one of the snow diggings. It was unfinished by musk deer. This case took place in the Kamenistaya River valley (right tributary of the Bolshaya Tynda River) in dense larch forest with spruces. Other remains of small mammals were also found in the musk deer rumens. In four rumens (25% of all samples) there were parts of bones,

skulls, balls of fur, upper jaw incisors, and a tail found. All these fragments belonged to two species: Laxmann's shrew and grey red-backed vole. Earlier there were cases of other species of even-toed ungulates eating small mammals (Mosolov & Fil, 2010). Until now there has been only one case of a musk deer eating small mammals described in literature. Thus, one vole was found on the territory of the Sakha Republic in the Verkhoyansk Mountains, according to the rumen analysis data (*n*=6) (Krivoshapkin, 2008).

Conclusion

Nutrition of musk deer varies during the snow period in the Tukuringra Mountain Range, that is related to the adaptation of animals to different habitats. Musk deer diet also depended on the depth of snow cover. The main types of forage were shrub lichens and shrubs. The musk deer prefers *Evernia mesomorpha* among all kinds of lichens. In the unfavorable conditions of food deficit (burnt woods, black birch forests with oaks), the importance of shrub and herbaceous forage increased, as well as that of the arboreal fungi. I have encountered the cases of musk deer consuming of small mammals. It may be related to the specific metabolism during the snow season and to the peculiarities of forage finding behavior during this period.

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