RESEARCH PAPER

DISTRIBUTION OF POISONOUS PLANTS IN BIOMES OF THE SOUTHERN FAR EAST OF RUSSIA

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Received: June 8th, 2023 / Accepted: September 4th, 2023 / Published: October 10th, 2023
https://DOI-10.24057/2071-9388-2023-2928

ABSTRACT. Poisonous plants are a collective group of plants of various systematic categories that contain phytotoxins that pose a potential danger to humans and animals. A number of publications both in Russia and abroad are devoted to the problem of patterns of distribution of plants hazardous to human health in connection with environmental factors. This work is a continuation of research into the spread of plants dangerous to humans in Russia. The aim of this work is ecological and geographical analysis of poisonous plants distribution in biomes of the Far East in Russia. Resulted from the research work on the territory of the far-eastern biomes of Russia we revealed 87 the most toxic vascular plant species that belong to 21 plant families. Some of the most poisonous plants of the Russian flora are plants of the genus *Aconitum*, of the family (Ranunculaceae). About 70 species of this genus grow in Russia, of which 40 are found only in the Far East, since this territory is considered the center of botanical diversity of the genus in question. The cartographical analysis showed that the highest number of poisonous plant species could be found in the south-east regions – in Primorye, the basin of Ussuri river, in the lower and middle course of the river Amur. Based on a map of Russian biomes, optimal habitats for poisonous plants were identified. Maximum number of *Aconitum* species, as the most poisonous genus of Russian flora, is in the mountain biomes and in the plain forest-steppe biomes in the Amur basin. The types of ecosystems with the maximum abundance and diversity of poisonous plants have been identified. The species richness distribution shows the concentration of poisonous plant species in small mountain biomes and in arid-like biomes. Correlation analysis of relationships between the number of plant species and climatic factors revealed the significant closeness of the correlation with the average annual air temperature (0,66). Maximum correlation closeness appeared to be between number of poisonous plant species per 10 000 km^2 and total number of vascular plants per 10 000 km^2 (0,81).

KEYWORDS: poisonous plants, regional biomes, climatic factors, cartographical and correlation analysis

CITATION: Dikareva T. V., Rumyantsev V. Yu., Soldatov M. S., Wang Li (LI Wang), Malkhazova S. M. (2023). Distribution Of Poisonous Plants In Biomes Of The Southern Far East Of Russia. Geography, Environment, Sustainability, 3(16), 43-51
https://DOI-10.24057/2071-9388-2023-2928

ACKNOWLEDGEMENTS: The methodological part of the work was supported by the Russian Science Foundation project No. 21-47-00016 «New and re-emerging natural infectious diseases in China and Russia: spatial-temporal analysis and assessment of transboundary risks».

The thematic part of the study was carried out within the framework of the Development Program of the Interdisciplinary Scientific and Educational School of Moscow State University named after M.V. Lomonosov «The future of the planet and global environmental changes».

Conflict of interests: The authors reported no potential conflict of interest.

INTRODUCTION

Poisonous plants are a combined group of plant species of various systematic categories which contain phytotoxins potentially dangerous for people and animals. The poisonous properties od plants formed in the process of evolution and are the significant mechanist in struggle for existence. According to the degree of toxicity, plants are divided into unconditionally poisonous and conditionally poisonous. The last ones are toxic only in certain seasons or in some habitats. The seasonality of the content of toxic substances is determined by the peculiarities of the functioning of various plant organs during year cycle: above-ground parts of the plant are most toxic during the flowering period; in underground organs, the amount of toxins increases during the winter dormancy; the majority of fruits in plants are highly toxic when ripe.

About four hundred poisonous plant species grow on the territory of Russia with various degree of toxicity. The systematic study of these plants began in the 1930s of XX century (Krechetovich 1931) and was devoted to the analysis of the biochemical and botanical characteristics of poisonous plants. Later, numerous reference books and monographs

on poisonous plants of the USSR and Russia appeared in the domestic literature (Gusinin 1962; Dudar 1971; Luferov 1995; Zoricov 2005), in which the poisonous plants are considered as important source of biologically active substances included into many medications. Studies of poisonous plants were also carried out in order to prevent and treat poisoning.

Numerous works of foreign authors are devoted to distribution, danger and use of poisoning plants (Unschuld 1985; Blake et al. 2007; Banasik and Stedeford 2014; San Andres Larrea et al. 2014; Bradberry and Vale 2016). In recent years many Chinese authors work in nearby territories studying poisoning plants and their possible use (Li et al. 2016; Zhang et al. 2021; Liu et al. 2022; Yahn and Chen 2022; Zhou et al. 2022).

A number of publications of the authors are devoted to the problem of the patterns of distribution of plants dangerous to human health in connection with some factors of their habitat (Dikareva and Rumyantsev 2015; Dikareva et al. 2017; 2018; 2022).

This work is a continuation of research on the distribution of plants dangerous to humans in Russia. Its purpose is to analyze the distribution of poisonous plants in the south of the Far East region in connection with environmental factors. The authors are aware that, for example, the Trans-Baikal Territory is not the Far East at all. However, the use of more strict wording would greatly complicate both the text and the title of the article. The tasks of the work included compiling a list of the most poisonous plants in the study area, conducting a statistical analysis of the relationships between the number of poisonous plant species in regional biomes and climatic indicators, and constructing appropriate thematic maps.

MATERIALS AND METHODS

This research work is based on the map "Biomes of Russia" (Ogureeva et al. 2018; 2020). 19 biomes with subbiomes of the Russian Far East are included into analysis (Fig. 1). The study area includes the territories of the Trans-Baikal, Khabarovsk and Primorsky Territories, the Amur Region and the Jewish Autonomous Region.

Of the approximately four hundred species of poisonous plants known in Russia according to the literature, 87 species were selected for analysis, which are common in the Far East and are definitely poisonous.All selected species are toxic to humans and contain large doses of toxic substances (alkaloids, saponins, flavonoids, bergapten, isobergapten, isopimpinelin, xanthotoxin, psoralen, etc.) (Orlov et al. 1990; Donchenko et al. 2009; Konovalova and Shevireva 2011, etc.)

One of the most poisonous plants of Russian flora are plants of the genus *Aconitum* (hereinafter referred to as aconites) from Ranunculaceae family (Avdeev and Ananiev 2010). All organs of all species of the genus contain alkaloids, primarily aconitine. About 70 species of this genus grow in Russia, 40 of which are found only in the Far East, since this territory is considered to be the center of botanical diversity of the genus under consideration (Luferov 1995). The 40 most toxic species of the genus were selected, for which the authors considered it interesting to compare their distribution with the distribution of other poisonous plants.

Data on the areals of poisonous species are obtained from the guides of higher vascular plants (Gubanov et al. 1995; Vascular…1996; Flora…1987-2003; and others), as well as from atlases (Atlas…1983; Agroecological…2015; Medical-geographical atlas…2019).

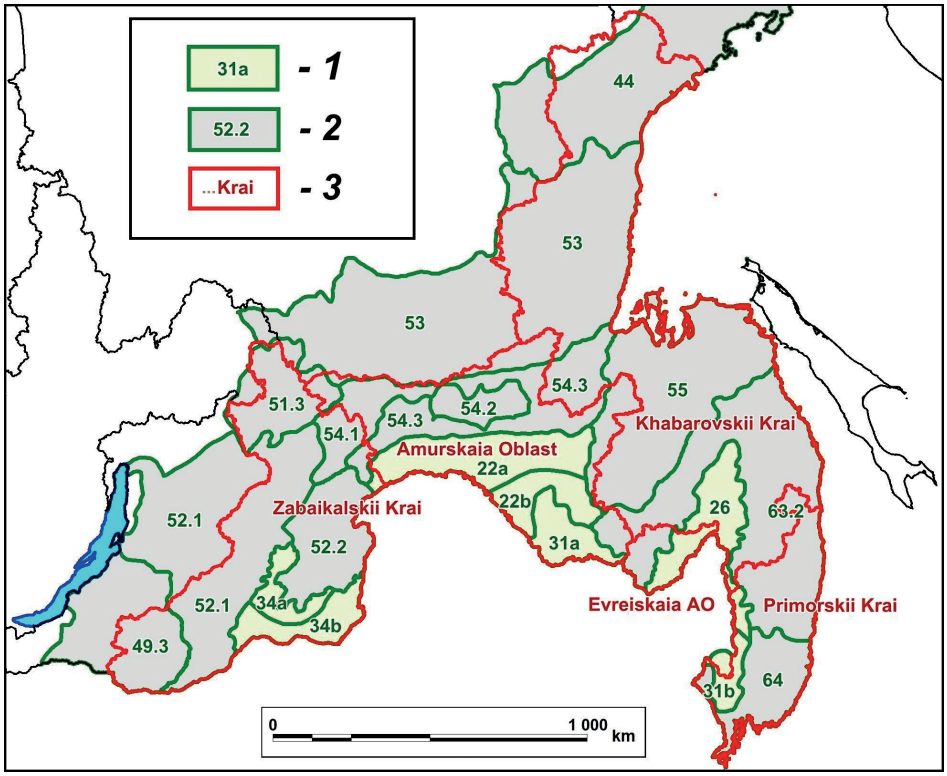

Fig. 1. Biomes (numeric designations) and subbiomes (letter designations) (source: Ogureeva et al. 2018; 2020) included in the analysis

1– Lowland:22 - Amuro-Zeiskii (a – southern taiga, b – subtaiga); 26 - Amuro-Ussuriiskii subtaiga; 31 - Zee-Bureinskii forest-steppe (a–Priamurskii oak forest-steppe, b–Prikhankaiskii pine-oak forest-steppe); 34 - Daurskii steppe (a - northern strip of forb-tussock-grass steppes, b - southern strip of forb-tussock-grass steppes).
2 – Mountain: 44 – Severookhotskii; 49 - Sayano-Yuzhnozabaikal'skii (49.3 - Buryatskii); 51 - Kodaro-Kalarskii (51.3 - Kodaro-Kalarskii); 52–Yuzhnozabaikal'skii (52.1–Vitimskii, 52.2 -Shilkinskii); 53 - Aldano-Maiskii; 54 - Yankan-Dzhagdinskii (54.1–Verkhnegilyuiskii, 54.2 - Tukuringra-Dzhagdinskii. 54.3 - Verkhnezeiskii); 55 – Yuzhnookhotskii; 63 - Sakhalino-Sikhote-Alin'skii (63.2 - Srednesikhote-Alin'skii); 64 - Sikhote-Alin'skii southern.
3– Subjects of the Russian Federation, limiting the study area.

The presence of a particular species of a poisonous plant in a biome was determined by the presence of at least a small part of its areal within a given unit (regional biome or subbiome). For each of the biomes, the total number of species of vascular plants was determined (taken directly from the map "Biomes of Russia" (Ogureeva et al. 2018; 2020) as well as number of species of poisonous plants (total, without *Aconitum* species and only *Aconitum* species). Next, the relative species richness of each regional division (biome or subbiome) was calculated, i.e., number of species per 10,000 km^2 for all species, poisonous species, poisonous species without *Aconitum* species and for *Aconitum* species. The materials are organized into a computer database linked to a digital base map in the MapInfo GIS (Fig. 1). On this basis, a series of maps of the distribution of all plant species and poisonous plants in the studied biomes was compiled.

The analysis included two climatic indicators – the average annual air temperature and the average annual precipitation. The relevant data was taken directly from the "Biomes of Russia" map (Ogureeva et al. 2018; 2020). If there was more than one value of this indicator for a biome (or subbiome), they were averaged. Working hypotheses were considered: 1) the number of poisonous plants depends on the total number of vascular plant species in a particular biome or subbiome; 2) the number of species of poisonous plants in a biome (subbiome) is directly related to climatic factors; 3) relative species richness (species per 10,000 km^2) of poisonous plants in a biome is related to the species richness of all vascular plant species in the biome (subbiome).To verify them, the Pearson pair correlation coefficients of the relationship between the number of plant species and environmental parameters were calculated in the STATISTIKA program for the traits listed below. The initial data for the corresponding calculations are presented in Table 1.

RESULTS AND DISCUSSION

The study area mainly refers to the Amur River basin, but also includes territories that do not belong to it. These are the eastern slopes of the Sikhote-Alin in the Primorsky region and the eastern slopes of the Dzhugdzhur Ridge in the north of the Khabarovsk region.

The territory of the region is mostly mountainous. Absolute heights are at 1000-2500 m above sea level. The appearance of the modern relief is determined by a combination of the sublatitudinal and submeridional location of the main mountain ranges, which form characteristic climatic barriers that prevent the penetration of oceanic monsoons far to the west. Therefore, the highest precipitation rates were noted in the coastal part of the region. The peculiarity of the nature of

Table 1. Characteristics of biomes and subbiomes included in the analysis

Biomes and subbiomes*	Square km^2	Average annual air temperature, C	Annual precipitation, mm	Total number of vascular plant species		Number of species of poisonous plants					
						all poisonous plants		aconites		without aconites	
				total	per 10000 km^2	total	per 10000 km^2	total	per 10000 km^2	total	per 10000 km^2
22a	90712	-3,97	421	1260	138,5	41	4,51	9	0,99	32	3,52
22b	38371	-3,6	540	1260	331,6	35	9,21	7	1,84	28	7,37
26	65743	1,5	645	1020	154,5	37	5,61	6	0,91	31	4,7
31	19234	2,7	625	800	421,1	35	18,42	9	4,74	26	13,68
31a	35063	-0,96	505	1000	285,7	46	13,14	11	3,14	35	10,0
34a	24187	-2,2	324	665	277,1	33	13,75	8	3,33	25	10,42
34b	39866	-3,2	300	657	164,3	23	5,75	8	2,0	15	3,75
44	410351	-3,3	536	1200	29,3	25	0,61	5	0,12	20	0,49
49.3	124568	0	342	1000	80,0	40	3,2	13	1,04	27	2,16
51.3	76393	-7,7	341	820	107,9	30	3,95	11	1,45	19	2,5
52.1	275599	-2,6	345	1550	56,2	33	1,2	12	0,43	21	0,76
52.2	83489	-5,4	427	1550	186,7	25	3,01	7	0,84	18	2,17
53	474314	-7,7	561	1100	23,2	18	0,38	7	0,15	11	0,23
54.1	52291	-4,7	579	1050	201,9	14	2,69	4	0,77	10	1,92
54.2	30149	-4,7	579	1050	350,0	18	6,0	5	1,67	13	4,33
54.3	120399	-4,7	579	1050	87,5	25	2,08	8	0,67	17	1,42
55	221424	-5,4	709	1130	51,1	34	1,54	7	0,32	27	1,22
63.2	272710	2,3	813	2000	73,3	43	1,58	12	0,44	31	1,14
64	63496	4,3	832	2535	402,4	43	6,83	11	1,75	32	5,08

* Indices – see Fig. 1.

the region is also determined by the fact that the territory has a characteristic mountain-valley relief structure, which provides a variety of natural conditions for the formation of vegetation cover.

Most of the biomes (and subbiomes) of the study region belong to the taiga hypoarctic type. They are located in the west and north of the study area. In the mountains, there is a vertical zonality of vegetation, in which the taiga belt, composed mainly of larch and, less often, spruce and fir forests, is replaced higher by subalpine stone-birch crooked forests and creeping forests. On many ridges in the upper bald belt, lichen groups are common, related to similar groups of plain tundra.

The biomes of Primorye are located at the junction of four geobotanical regions (Manchurian, Okhotsk, East Siberian and Daurian). In Primorye, on the plains and lower slopes of the mountains, there are specific broad-leaved and coniferous-broad-leaved forests. The presence of heat-loving relict tertiary plants belonging to the so-called "Manchurian flora" is a characteristic feature not only of Primorye, but of the entire Amur basin.

On the Zeya-Bureya plain, located in the middle reaches of the Amur, as well as on the Khanka-Ussuri lowland of the Ussuri river basin, forest-steppes are widespread. This is due to the fact that these plains are delimited from the sea air masses by the Bureinsky and Sikhote-Alinsky ridges, as a result of which conditions are created for the formation of a more continental climate, which contributes to the development of the forest-steppe.

With distance to the west from the sea coast, the continentality of the climate increases, which largely influences the formation in Transbaikalia, on the plains surrounded by mountain ranges, of peculiar steppe communities belonging to the Daurian steppe biome.

The species of poisonous plants included in the analysis belong to 21 families. The largest number of species belongs to the Ranunculaceae family – 44 species including 40 species of *Aconitum* genus. Equisetaceae and Melanthiaceae families include 6 species of poisonous plants each. Solanaceae family – 4 species, Apiaceae – 3 species, Rutaceae – 2 species of poisonous plants. The remaining families (15) include one species of poisonous plants each. Table 2 lists poisonous plants that are found in more than 50% of the biomes and subbiomes included in the analysis.

Table 2. Species of poisonous plants found in more than 50%considered biomes and subbiomes

№	Poisonous species	Biomes number	
		number	% of total
1	*Andromeda polifolia* L.	18	95
2	*Equisetum arvénse* L.	17	89
3	*Ranunculus sceleratus* L.	17	89
4	*Equisetum sylvaticum* L.	16	84
5	*Equisetum pratense* Ehrh.	16	84
6	*Actaea erythrocarpa* (Fisch.) Freyn	16	84
7	*Erýsimum cheiranthoídes* L.	16	84
8	*Polygonatum humile* Fisch. Ex Maxim.	15	79
9	*Equisetum fluviatile* L.	14	74
10	*Equisetum palustre* L.	14	74
11	*Ledumpalustre* L.	14	74
12	*Calla palūstris* L.	14	74
13	*Polygonatum odoratum* (Mill.) Druce.	14	74
14	*Convallaria keiskei* Mio.	14	74
15	*Aconitum sczukinii* Turcz	13	68
16	*Cicúta virósa* L.	12	63
17	*Huperzia selago* (L.) Bernh. ex Schrank & Mart.	12	63
18	*Menispermum dauricum* DC.	11	58
19	*Dictamnus dasycarpus* Tursz,	11	58
20	*Heracleum sosnowskyi* Manden.	11	58
21	*Aconitum ranunculoides* Tursz ex Ledeb	11	58
22	*Cánnabis satíva* L.	11	58
23	*Veratrum lobelianum* Bernh.	10	53
24	*Aconitum macrorhynchum* Tursz ex Ledeb.	10	53

Only 24 of the 87 dangerous plant species are commonly found in biomes and subbiomes. Some species of this group have wide ranges and are distributed mainly in disturbed communities – for example, *Equisetum pretense* L. and *E. arvénse* L., *Ranunculus sceleratus* L., *Cánnabis sativa* L., *Erýsimum cheiranthoídes* L., *Heracleum sosnowskyi* Manden. The specificity of the region reflects a significant number of aquatic and semi-aquatic plants. They are *Equisetum fluviatile* L. and *E. palustre* L., *Cicúta virósa* L., *Calla palūstris* L. and *Ledum palustre* L. The remaining species are predominantly forest plants.

Although aconites make up almost half of the total list of poisonous plants in the region, only three species are found in more than 50% of biomes and subbiomes. They are *Aconitum sczukinii* Turcz, A. *macrorhynchum* Tursz ex Ledeb. And *A. ranunculoides* Tursz ex Ledeb, usually confined to numerous river valleys. The remaining species of the genus are limited in distribution, which is generally characteristic of endemic relict plants.

To conduct a correlation analysis, the following factors were taken as factors that can affect the number of poisonous plant species in a biome or subbiome: 1) average annual air temperature, C°; 2) annual amount of precipitation, mm; 3) total number of vascular plant species in a biome or subbiome; 4) number of vascular plant species per 10,000 km^2 (relative species richness). We consider the number of plant species, both poisonous and all vascular (absolute and per 10,000 km^2), to be features that probably depend on these factors. Thus, factors 3 and 4 are both features.

The results are presented in Table 3. In the column "factors", 3 and 4 – correspond to the total number of poisonous species (87) and the number of species of poisonous plants without species of the genus Aconite (47), because they act here as "factors". And the column of indicators is the number of species in each biome (sub biome).

An analysis of the relationship between plant species, including poisonous ones, and climatic indicators showed a significant closeness of the relationship between the number of poisonous species without aconites, the total number of poisonous species in biomes and the average annual air temperature – the correlation coefficient is 0.66. However, for aconites, this figure turned out to be quite low – only 0.40. A relatively high correlation coefficient was obtained for the relationship between the total number of vascular plant species and the annual amount of precipitation (0.59). But the tightness of the relationship between the number of poisonous species and the annual amount of precipitation turned out to be minimal (0.02-0.26). Thus, no clear links between the number of species in the territory and climatic factors have been identified.

The maximum tightness of the relationship (0.79-0.81) was found between the number of poisonous species per 10,000 km^2 and the total number of vascular plant species per 10,000 km^2. At the same time, the tightness of the relationship between the total number of vascular plant species and the number of poisonous species is only (0.31-0.36). The distribution of relative species richness demonstrates the concentration of poisonous species in small mountain biomes – Sikhote-Alin, Yankano-Dzhagda and in arid biomes – Daursky steppe, Amur-Zeya forest-steppe. This is explained by the fact that a small mountain biome with a dissected topography, elevation changes, microclimate regimes, soils objectively demonstrate a higher diversity of species, and also confirms the hypothesis that higher temperatures contribute to the concentration of poisonous plant species.

Analysis of the data given in Table 2 and in Fig. 2 clearly showed that the largest number of vascular plant species includes the southern Sikhote-Alin biome (64), located in the south of Primorsky Krai, as well as the middle Sikhote-Alin biome (63.2), also located in favorable climatic conditions. The second place in terms of the number of species is occupied by the taiga hypoarctic biomes – Vitimsky and Shilkinsky (52.1, 52.2), located in Transbaikalia, in the southwest of the study region. The smallest number of species is naturally noted for biomes experiencing a moisture deficit – the Daurian steppe biome (34) and the Zee-Bureya forest-steppe biome (31).

A different picture is observed when calculating species richness per 10,000 km^2. Relatively small biomes have the highest relative species richness: steppe (34), forest-steppe (31), subtaiga (22b), mountain subbiomes of the Yankano-Dzhagda biome (54.1, 54.2), as well as the southern Sikhote-Alin nemoral biome (64). In the latter, the number of species and relative species richness are the highest among others in the region. Large taiga biomes – Severo-Okhotsk (44), Aldan-Mai (53), South-Okhotsk (55) biomes, having average indicators for the total number of species, are characterized by the lowest relative species richness.

Table 3. Pearson pair correlation coefficients (n = 19)

Features (number of plant species)	Factors			
	1	2	3	4
All species of vascular plants	0,43	**0,59**	---	---
Number of species of vascular plants per 10 000 km^2	0,44	0,20	---	---
All species of poisonous plants – total 87	**0,66**	0,19	0,36	---
All species of poisonous plants – per 10 000 km^2	0,44	0,05	---	**0,81**
Poisonous species without aconites – total 47	**0,66**	0,26	0,33	---
Poisonous species without aconites – per 10 000 km^2	0,45	0,02	---	**0,81**
Poisonous species of aconites – total 40	0,41	-0,13	0,31	---
Poisonous species of aconites – per 10 000 km^2	0,40	0,12	---	**0,79**

All correlations are significant at $p < 0.05$.
Cases with closeness of connection more than **0.50** were marked bold.

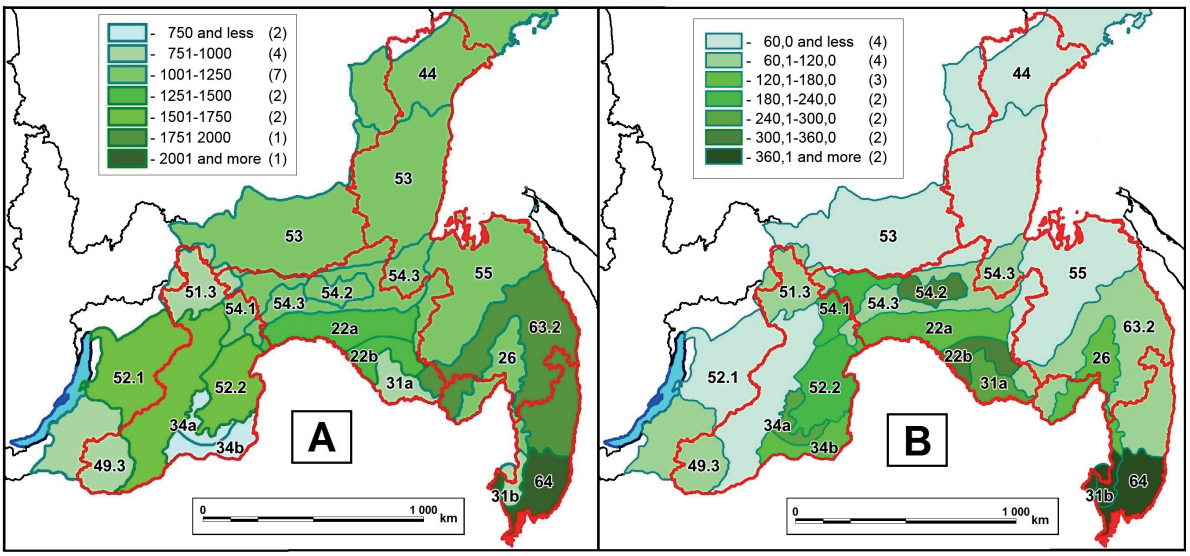

Fig. 2. Total number of vascular plant species

A – total number of vascular plant species in a biome (subbiome);
B – number of vascular plant species per 10,000 km^2 (relative species richness). Here and below: in parentheses, the number of map sections (biomes and subbiomes) in a given gradation.

The map (Fig. 3) reflects the distribution of all poisonous plants (including aconites) in the biomes and subbiomes of the study region.

The largest number of poisonous species was noted in the Amur and Ussuri basins (31, 22, 26) and in the east of the region, in the biomes of Primorye (64, 63.2). A relatively high number of species of poisonous plants is observed in the western mountain-taiga biomes of Transbaikalia: Buryat (49.3), South-Zabaikal (52.1), and steppe Daur (34a). A low abundance of poisonous species was found in the mountain biomes directly adjacent to the Amur (54.3) or its large first-order tributaries, the Zeya and Bureya (54.3), as well as in the Severo-Okhotsk biome (44), located in the north of the study region. An extremely low number of species is typical for small mountain biomes (54.1, 54.2) and for the large Aldan-Maya biome (53).

The distribution of relative species richness is determined by the size of biomes or subbiomes, that is why it is especially high in small territorial units. These are mainly subbiomes of arid appearance – Daursky steppe (34a), Amur-Zeya forest-steppe (31). The average relative species richness of poisonous plants was noted in the Daurian steppe (34b), the southern Sikhote-Alin biome of mixed forests (64), and the Amur-Ussuri subtaiga biome (26). The mountain taiga biomes Buryatsky (49.3), Vitimsky (52.2), Kodaro-Kolarsky (51.3), subbiomes of the Yankano-Dzhigda biome (54.1, 54.2) are characterized by low relative species richness. The remaining biomes are characterized by extremely low relative species richness.

The map (Fig. 4) reflects the distribution of poisonous plants in the biomes of the region, excluding aconites, which are considered separately below.

The distribution of relative species richness of poisonous plants (Fig. 4A) shows that the largest number of species of poisonous plants is observed in the east of the region, in the biomes of Primorsky Krai (63.3, 64), as well as on the plains, in biomes immediately adjacent to the channels of the Amur and Ussuri (26), including forest-steppe biomes (22a, 31a). The average abundance of poisonous plants was noted in the western and southwestern mountain taiga biomes (49.3, 52, 51.3), as well as in the Daurian steppe biome (34). The smallest abundance is observed in the large mountain Aldan-Maya biome (53), as well as in the small mountain subbiomes of the Yankano-Dzhagda biome (54).

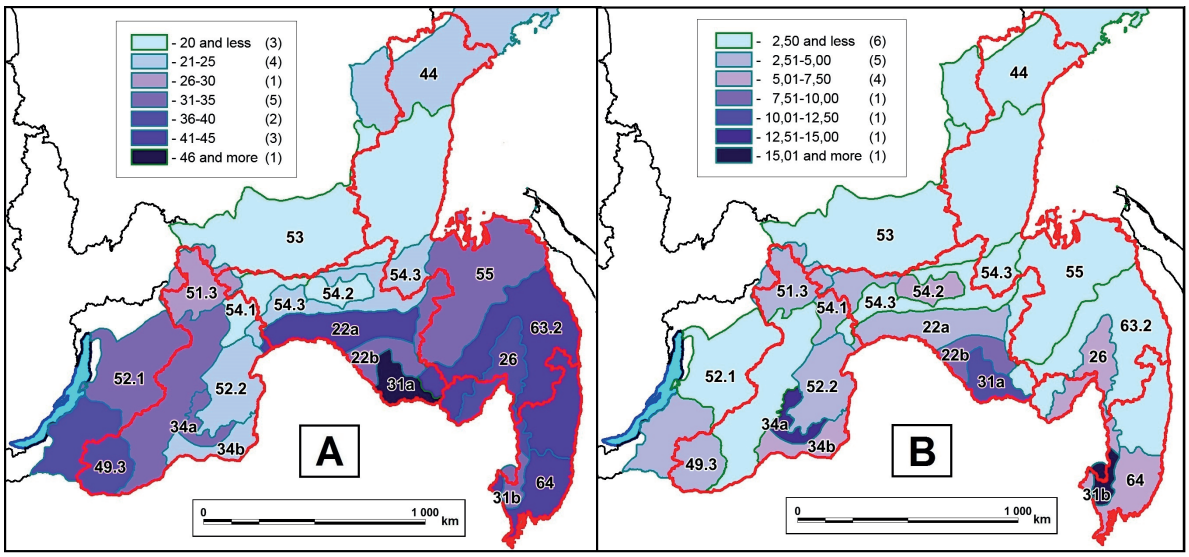

Fig. 3. Total number of poisonous plant species (including aconites)

A – total number of species of poisonous plants in the biome (subbiome);
B – number of poisonous plant species per 10,000 km^2 (relative species richness)

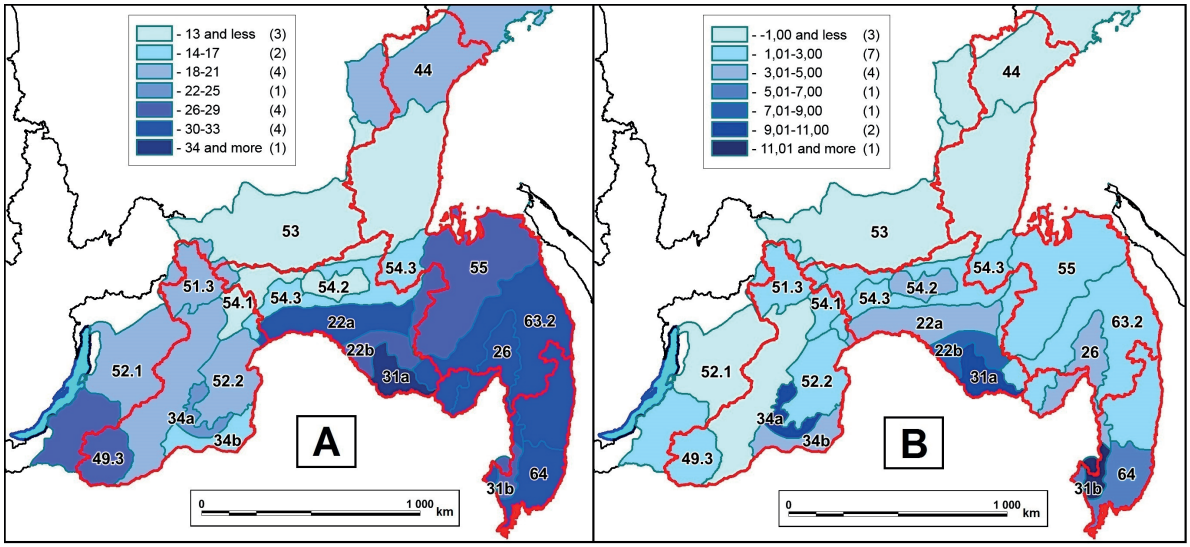

Fig. 4. Number of species of poisonous plants without aconites

A – total number of species of poisonous plants without aconites in the biome (subbiome);
B – number of poisonous plant species without aconites per 10,000 km^2 (relative species richness)

The relative species richness of poisonous plants is distributed somewhat differently (Fig. 4B). Relatively high species richness or density of species was noted in the biomes of Primorye and the Amur Region. At the same time, the highest relative species richness is characteristic of biomes with small areas: Daurian steppe (34), Zee-Bureya forest-steppe (31), and nemoral forest southern Sikhote-Alin (64).

The distribution of the number of species of the genus *Aconite* (Fig. 5A) shows that their greatest number was recorded in the mountain-taiga Buryatsky (49.3), South-Zabaikalsky (52.1), Kodar-Kolarsky (51.3) and in the forest biomes of Primorye (63.2, 64). A significant number of aconite species have been identified in forest-steppe biomes (31). In most of the biomes of the region, with the exception of small mountain-taiga subbiomes (54.1, 54.2), the number of *Aconite* species is average.

The distribution of relative species richness of *Aconites* in the biomes of the region (Fig. 5B) is characterized by the fact that the highest density of species was noted in small subbiomes – Zee-Bureya (31), Daursky (34a). A relatively high density was found in the southern Sikhote-Alin biome (64), small mountain subbiomes of the Yankano-Dzhagda biome (54). In general, a relatively noticeable species richness is characteristic of subbiomes directly adjacent to the channels of the rivers Amur, Zeya, Bureya, Ussuri.

Thus, the largest number of all vascular plants includes the Sikhote-Alin biomes (63.2 and 64) – 2000–2535 species, respectively. The Transbaikalian biome contains somewhat fewer species (52.1, 52.2) – 1550 species. A relatively high number of species includes the Amur-Zeya southern taiga biome (22) – 1260 species. The smallest number of species among other biomes was noted in the Daursky steppe (34) – 657 species.

The largest number of poisonous plants is characteristic of the Amur forest-steppe subbiome (31a). Slightly fewer species were recorded in the biomes of Primorye (63.2, 64), as well as in the Amur-Zeya southern taiga (22a). The smallest number of poisonous plants is characteristic of the Upper Gilyui subbiome (54.1), located on the watershed of two large river basins, the Lena and Amur.

It should be noted that the highest average annual air temperature and total precipitation are characteristic of the biomes of Primorye (63.2, 64). In this case, this generally corresponds to the number of plant species, including poisonous ones. However, this pattern is weakly observed

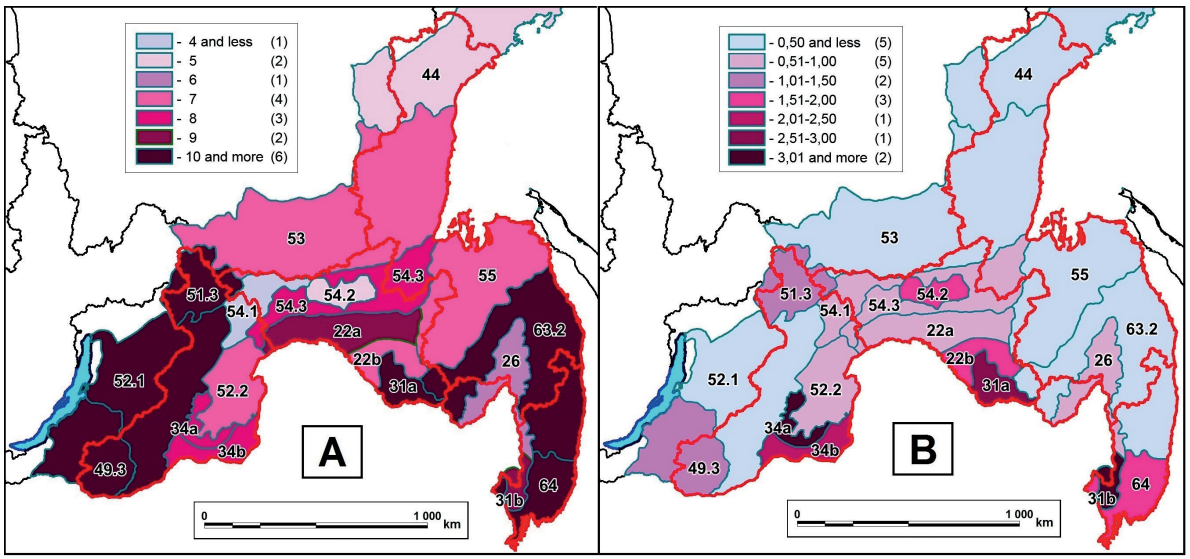

Fig. 5. The number of species of poisonous plants –*Aconite* genus

A – total number of species of poisonous aconites in the biome (subbiome);
B – number of poisonous aconite species per 10,000 km^2 (relative species richness)

for other biomes. For example, the low abundance of all species in the Daurian steppe biome corresponds to a low amount of precipitation, but does not correlate with the average annual air temperature.

CONCLUSION

The list of poisonous plants of the Far East region includes 87 plant species belonging to 21 families. The largest number of species belongs to the Ranunculaceae family – a total of 44 species. Of these, 40 species are plants of *Aconitum* genus – the most poisonous species in Russian flora.

The largest number of species of all plants includes the southern Sikhote-Alin biome, located in the south of Primorsky Krai, and the middle Sikhote-Alin biome, also located in favorable hydrothermal conditions. Relatively small biomes have the highest species richness – steppe (Daurian steppe), forest-steppe (Zeya-Bureinsky forest-steppe, Amur-Zeya subtaiga), mountain subbiomes of the Yankano-Dzhagda biome, as well as the southern Sikhote-Alin nemoral biome.

The largest number of poisonous species was noted in the east of the region – in the biomes of Primorye, in the Ussuri basin, in the lower and middle Amur. The relative species richness of poisonous species is higher in arid subbiomes – Daurian steppe, Amur-Zeya forest-steppe. The distribution of the species richness of poisonous plants without aconites shows that their greatest number is observed in the east of the region, in the biomes of Primorsky Krai (Middle Sikhote-Alin and Sikhote-Alin southern), as well as on the plains, in biomes immediately adjacent to the channel of the Amur and Ussuri (Amur -Ussuri subtaiga), including forest-steppe biomes (Amur-Zeya subtaiga and Zee-Bureinsky forest-steppe Amur oak forest-steppe). Their relative species richness is distributed somewhat differently. In general, the trend continues; relatively high species richness was noted in the biomes of Primorye and the Amur Region.

An analysis of the distribution of the number of aconite species shows that it is maximum in the mountain forest biomes of Primorye (Middle Sikhote-Alin and Sikhote-Alin southern), as well as on the plains of the Amur valley in forest-steppe biomes (Zeya-Bureinsky forest-steppe). The distribution of relative species richness of *Aconites* in the biomes of the region is characterized by a maximum in small subbiomes – Daursky, Zee-Bureinsky.Highrichness was found in the southern Sikhote-Alin biome, in small mountain subbiomes of the Yankano-Dzhagda biome. Relatively high species richness is typical for subbiomes directly adjacent to the channel of the rivers Amur, Zeya, Bureya, Ussuri.

An analysis of the relationship between plant species, including poisonous ones, and climatic indicators revealed a significant closeness of the relationship between the number of poisonous species without aconites, the total number of poisonous species in biomes and the average annual air temperature – the correlation coefficient is 0.66, however, the closeness of the relationship between the number of poisonous species and the annual amount of precipitation was minimal (0.02-0.26). The closeness of the relationship (0.79-0.81) between the number of poisonous species per 10,000 km^2 and the total number of vascular plants per 10,000 km^2 is maximum. At the same time, the tightness of the relationship between the total number of vascular plant species and the number of poisonous species is only (0.31-0.36). All correlations are significant at $p < 0.05$. Thus, "hypothesis 3" was most confirmed, and "hypothesis 2" (see "Materials and methods") was partially confirmed.

The patterns of distribution of plant species dangerous to human health and their relationship with environmental factors are practically not studied. This work represents only one of the initial approaches to understanding these patterns. In the future, the authors plan to conduct a similar analysis for allergenic plants.

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