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Structural identification of mulberry forms anatomical features

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A B S T R A C T

The article discusses the new forms of mulberry that have been studied for the structural-anatomical, identification, and coefficient characteristics of the leaf. The analysis shows that the mulberry forms N1 and N3 were obtained from the diploid origin of Morus alba Linn species, while N7 belongs to the natural polyploid. Form N1 is recommended for use in leaf direction-silkworm breeding, while Forms N3 and N7 are more effective for canning purposes. Also, mulberry forms N1 and N3 can be propagated in the leaf blight multiplication zone as high-endurance donors (number of soft leaves 14.8; 14.4, respectively).

Key words: Correlation mesophyll, Laphanum, Cytolith, Stalk, Mesopetsy, Mulberry.

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Introduction

The anatomical structure of the mulberry plant is genetically determined point, which does not change under the influence of external factors, is manifested by various chemical-physiological processes and is reflected in the potential durability and productivity of the variety, thus the study of anatomical structure is one of the essential fields for the identification of the mulberry variety and shape and for the preliminary prediction of scientific indicators.

Mulberry is an important crop not only in silk industry but also in terms of use in pharmacology and canning. Recently, highly productive breeding species have become extinct and degenerated in neglected plantations, resulting in numerous new forms of natural breeding that deserve to be used in production .Morphological anatomical and biochemical methods are used to identify them. One of the methods is to study the high productivity and durability of the individuality of the species by studying the diagnostic structural-anatomical features [1,2].

In the practice of breeding, the identification of the species is obtained by the shape and volume of the cystolites in the leaf mesophyll, and the amount of extra soft leaf (> 10) in the medullary part of the stalk is used as a marker of phytoplasmic disease resistance to leaf rot [1,3].

The study of the forms and varieties of mulberry with phenotypic signs, anatomical and chemical analysis methods, together allows to find out the direction and expediency of their use [4].

Material and methods

Mulberry forms with conditional numbers N1, N2, N3 were selected as the object of research. N1 of them is a male plant in Imereti region (shadow-2) N3 is a female plant selected in Shida Kartli (Saguramo), and N7 in Samtskhe-Javakheti (Vardzia 7) is a medium-sized plant with dark fruits. With green and leaves of good consistency. From their leaf specimens, lumps were prepared on a microtome with a thickness of 9 mk, treated with a 24-hour exposure to francanium solution, and examined by stereomicroscope using MBI-6.

Results and discussion

The shape of mulberry N 1 is bifacial with the anatomical structure of the leaf, the length of the plate is 10.8.9 cm, the thickness of its assimilating tissue is 75.8 on average, the upper and lower epidermis are single-limbed. And the cloud parenchyma is 41.9 (Table) Form N1 is characterized by a small, closely interconnected parenchyma. The number of drusions of different sizes in the tissue of the upper epidermis, the small size and the size of the intracellular space have a substantial effect on the leaf viability and permeability of the leaf.

The stalk structure of Form N1 is characterized by frequent thickening, medium-thick cuticle, the permeable system is arcuate and intermittent. In the edular part are located the vital type cells with an additional soft larynx, 14.8 units are found in the acid crystals of acid-druze, which substantially affects the acidity of the leaf [4].

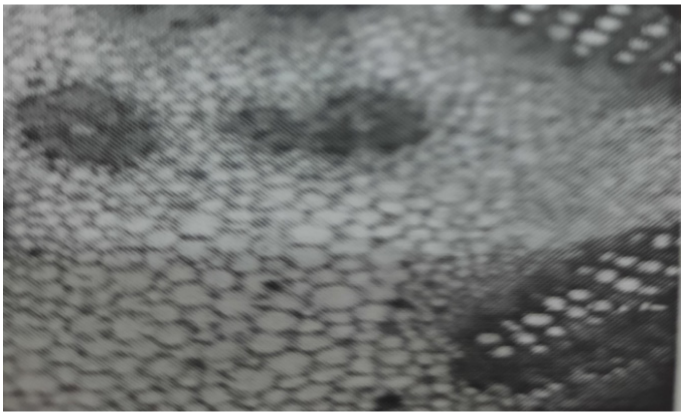

Fig. 1. *Mulberry form N 1 Constituent elements of the anatomical structure of the stalk and twig. Extra soft lap.*

Mulberry form N 3 (Saguramo) is an abundant female form. Its leaf blade is quite thick - 111.5 mesophilic - 85.3 - the upper and lower epidermis is single-stemmed. The tissue of the upper epidermis is 20.3, while the lower 8.2 mesenteric parenchyma is bilayer, its thickness is equal to 31.8, and the thickness of the cloudy parenchyma is 42.2.

The leaf of N 3 is characterized by a dense cellular structure, located in the upper epidermis, cysts of one type and different sizes are observed in small numbers, characterized by a frequent arrangement of simple conductive tissue, the conductive vessels are spiral, rarely circular. The leaf is unbroken, the trichomes are fixed only on the abaxial side of the leaf. It is of two types: simple-conical, erect and simple glandular spheres. Leaf ventilation apparatus belongs to the ascending type Medium-sized baguettes are located chaotically on the underside.

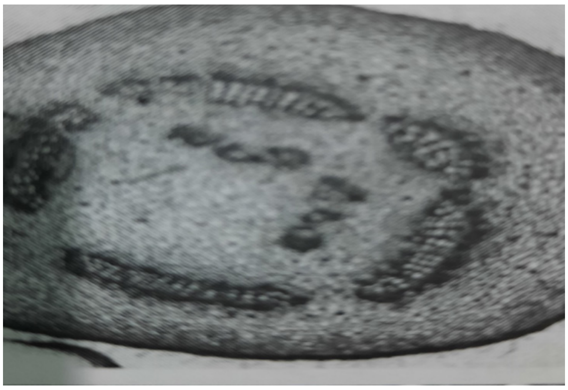

Fig. 2. *Mulberry Form N 2 Donziventral mesophyll of leaf bifacial plate. Meseric, mesernial, cloudy parenchyma*

The leaf stalk is almost indistinguishable, with rarely slightly curved simple trichomes. The cuticle is of medium thickness, with a dense cellular structure. The conductive system is arranged in a circle. Chadian rays are found in the wood. The leaf stalk also has a small number of druids, the number of soft laurels is 14.4 units.

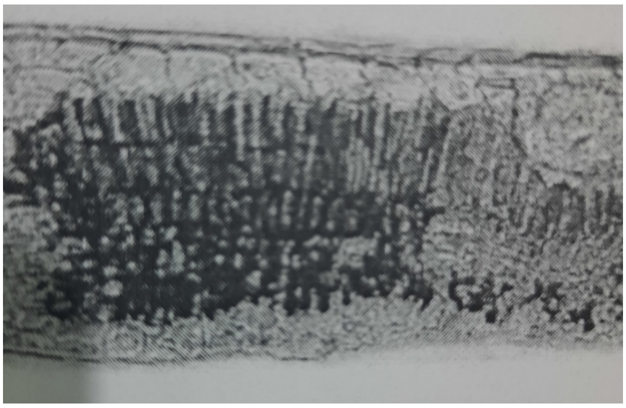

Fig. 3. *Mulberry form N 3 Transverse incision of the stalk: trichomes, cuticle, continuous tissues of the plate colenchem and mesoderm*

The leaf of the mulberry form N 7 (Vardzia) is bifacial, the sisike of the plate is 75.9. The upper and lower epidermis are single. The thickness of the upper epidermis is 22.3, and the lower epidermis is 10.6. Messernier parenchyma is two-layered with a thickness of 33.08 Cloudy parenchyma-42.4.

Mulberry form N7 leaf is characterized by a sharply mottled and dense cellular structure of mesophyll. Two types of cystoliths are located in the upper epidermis, their size is heterogeneous. Druses are fixed in average numbers. The thickening of the conductive skin is spiral, rarely it is also found in the ring, the leaf is weakly covered with trichomes fixed on the apical side of the leaf. There are both types - both simple conical and simple glandular - spherical.

Ventilation device - bug is found on the lower epidermis of the leaf, asecta type. It is characterized by medium-sized chaotically located bugs.

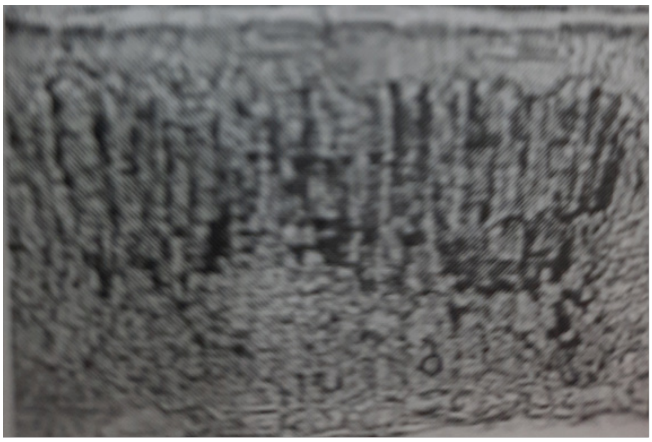

Fig. 4. *Mulberry Form-7 Lower cells of the lower epidermis with ascending type buds*

The leaf stalk of these forms of mulberry (N7) is characterized by weak sheath, dense cellular epidermis, voluminous tissues of the colenchem and mesoderm. Lapis fibers and mesoderm tissue of different sizes are lined up, and giant-sized druids are also observed in units. Spiral vessels and radial rays are differentiated in wood. Extra soft tissue cells are equal to 10.7 units per mesopectol (Fig. 4).The digital material of the constituent elements of the leaf mesophyll structure of the above forms is given.

Table. *Mulberry is a new form of leaf mesophyll dimensions*

Name of mulberry forms	**N1, Male**	**N2, Female**	**N3, Female**
Leaf plate thickness, ɥ	108,9	111,5	130,3
Mesophilic thickness, ɥ	75,8	85,3	75,9
Thickness of mesenteric tissue, ɥ	29,0	31,8	33,0
Thickness of cloudy tissue, ɥ	41,9	42,2	42,4
Thickness of the upper epidermis, ɥ	20,2	20,3	22,3
Quantity of Extra soft lap points	14,8	14,4	10,7

Conclusion

According to structural-anatomical identification studied by us and by analyzing the correlation characteristics it becomes clear that:

Mulberry forms N1 and N3 were obtained from diploid origin of Morus alba Linn species, while N7 should be attributed to natural polyploidy;

Form N1 should be used as a leaf-oriented silk industry, while Forms N3 and N7 will be more effective for canning purposes;

Mulberry forms N1 and N3 can be propagated in the leaf blight multiplication zone as high-endurance donors (number of soft leaves 14.8; 14.4 respectively).

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Aspects of ecological conditions of Sheki and Oguz regions

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A B S T R A C T

At present, the violation of the ecological environment in the country, the reduction of forests, meadows, agricultural lands, the complete destruction of some places, the violation or reduction of biological diversity of some plant and animal species increase the relevance of ecology and environmental assessment.

***Key words*:** Fertility of soils, Agricultural lands, Environmental assessment, Climatic elements.

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Introduction

The region is located in the north-west of the republic, in the north-west and in the south along the Alazan River in the Republic of Georgia, in the north along the southern slope of the Greater Caucasus to the beginning of the Goychay River in the Dagestan Autonomous Republic, and in the south in the Alazan-Haftaran valley and Samukh in the south. and Agdash and Goychay districts in the south-east.

Covering the administrative districts of Balakan, Zagatala, Gakh, Sheki, Oguz and Gabala, the total area is 883.5 thousand hectares or 10.2% of the country's territory. The relief is mostly mountainous. The mountainous area itself is divided into high mountainous, medium mountainous and foothill zones. In the south, the Alazan-Haftaran valley stretches from west to east, parallel to the foothills. The valley plays an important role in the region's economy due to its agricultural land resources.

The region is characterized by a very complex shape in the fragmented relief of the area, varying in width over a distance of 4480 m to the high Bazarduzu Mountain, which starts at about 100 meters from the shore of the steppe Achinohur. Widespread erosion events also play an important role in the formation of the relief. Frequent floods in the region are due to the location of large river networks and high slopes, as well as high rainfall [1].

Thus, a very complex and sharp change in the relief conditions in the area along the vertical belt has led to the formation of different climate types. Thus, all climatic elements are unevenly distributed in the area due to the increase in altitude from the south-west to the north-east of the semi-desert, dry steppe cold and mountain tundra climate types. According to the climatic indicators of Zagatala meteorological station in the north-west of the area, the average annual temperature is 12.50. The cold season of the year is characterized by 2.10 in winter and 22.90 in the hot season, in summer. In the cold season, the temperature does not exceed 5.60, while in the warm season it reaches 19.40. According to the observations of the Sheki meteorological station in the central part of the area, these figures are slightly different. Thus, the average annual temperature is 0.50 in winter and 0.20-0.40 in summer. In the city of Gabala, which ends in the east, the corresponding figures are between 0.20 and 21.00, and even the difference in average temperature is 1.90 lower than in Zagatala. The amount and distribution of precipitation in the area are quite different.

While the annual rainfall was 622 mm in Muganli settlement, 1394 mm drop was recorded in Alibey meteorological station located at 1750 m altitude on the southern slope of the range. As can be seen from the figures, the amount of precipitation in the region, as a rule, increases with increasing altitude. Precipitation is unevenly distributed throughout the year. According to the observations, the amount of precipitation in the form of rain in the maximum warm period varies between 408-875 mm, and in the cold period - 214-574 mm. Precipitation in the region, mainly in the hot season, often intensifies the process of erosion and floods in the area. The average annual relative humidity varies between 70-79% between individual points. Evaporation of moisture from the surface is also very different. The highest possible evaporation in the area was recorded at the Muganli meteorological station located on a dry steppe.

Objects and methods

Like indicators of other climatic elements, the surface temperature of the soil cover in the region depends on the relief structure of the area, vegetation, granulometric composition of the soil, etc. changes depending on factors. Thus, while the average annual surface temperature is 7.00 in Alibey meteorological station, in Gabala and Zagatala this figure rises to 13-150. Even in the cold season, this figure falls to 1.50 in the mountains, and at the same time in the foothills does not fall below a positive 3.70. Similar features are also observed in the dynamics of changes in soil temperature. Thus, in the zones described above, different vegetation is formed depending on the relief and climatic conditions. Acinohur steppe, located in the south of the Alazan-Haftaran valley, has dry steppe and semi-desert vegetation and xerophytic shrubs. Acinohur steppe, which covers the territory of Gakh and Sheki regions, is used as winter pastures. The vegetation of the Alazan-Haftaran valley, which is surrounded by the Acinohur front rock to the south and consists mainly of a lowland, is composed of shrubs and meadows. Crabs grow wild fruits (apple, cherry, mashed, cornel, etc.). Due to the wide use of the valley in agriculture, natural vegetation is poorly developed. In the past, widespread and impassable lowland forests in the valley were exposed to anthropogenic influences over time and were cut down in many areas, and the lands began to be used for agriculture. In some places, the forest cover preserved in the form of steppes now belongs to the state forest fund. Broad-leaved forests are also widespread in the region on the mountain slopes of this part of the Greater Caucasus.

The lower forest belt in the area is located at an altitude of 500-600 m to 900-1000 m above sea level. In these sparsely wooded forests located in the anthropogenic zone, along with hornbeams, oaks, shrubs, hawthorn, mulberry, black currant, cornel, cherry, hazelnut, etc. spread. In the middle mountain range, the bushes are substantially reduced and the predominance of beech trees is observed. The mesophilic beech forest, which covers an area of 1,000 to 1,700 meters, is also home to some species of Caucasian hornbeam and birch[4]. Upper mountain forests are spread at an altitude of 1700-2200, 2400 m. These forests are sparse, short and well developed with grass cover. The southern slopes are dominated by oak forests, while the northern slopes are covered with oak and beech forests. Sometimes spruce is replaced by birch, spruce and maple. Apart from trees of great economic importance in the mountain forests of the region, apples, pears, walnuts, hazelnuts, chestnuts, cornel, raspberries, cherries, hawthorn, etc. wild fruit trees are also widespread. Also very valuable medicinal plants for the pharmaceutical industry in the mountain forests of the region. The high mountain belt of the region consists of subalpine and alpine meadows. Subalpine meadows are rich in species, coniferous and mainly composed of perennials. The evergreen Caucasian rhododendron is found in certain areas on the subalpine humid northern slopes. Subalpine meadows, consisting mainly of tall wild grains and grasses, are replaced by real alpine plants at altitudes of 2500-2600 m. They form grass and stick to the ground in the form of “dots”. That is why they are also called alpine carpets. Alpine meadow plants are short in size and few species. Different types of mosses and sedges are spread in the snow-covered heights of the area. Only a small amount of mountain rocks or sparse low-growing grasses grow among the eroded rock fragments are found here.

Experimental part

Alpine meadows are a valuable and useful pasture for sheep. The current condition of most pastures in the region is very bad. Thus, the biological productivity of summer pastures decreases from year to year. The geobotanical composition of the grass cover is deteriorating. The area of eroded areas continues to expand from year to year.

Thus, the vegetation formed in the zones described above, depending on the relief and climatic conditions of the area, also determined the distribution of soils according to the law of horizontal zoning [6]. The composition of the land cover of the region, which does not have such large land reserves, consists of different types and subtypes of soils.

The composition of the land cover of the region

Number	Type and subtypes	Area	
		ha	%
1	**2**	**3**	**4**
1	Primary and peat mountain-meadow	37092	4,2
2	Grassy mountain-meadow	40778	4,6
4	Steppe mountain-meadow	12576	1,4
5	Meadow mountain-forest	5938	0,7
6	Tipical brown mountain forest	153681	17,4
7	Carbonate residue, partially deserted brown mountain-forest	89506	10,1
12	Washed brown mountain forest	31472	3,6
13	Typical brown mountain-forest	6606	0,7
14	Carbonate and partially deserted brown mountain-forest	3394	0,4
15	Washed and typical mountain-black	6872	0,8
16	Carbonate mountain black	22790	2,6
18	Light mountain gray-brown	18110	2,0
19	Dark and ordinary mountain chestnu	6032	0,7
20	Partially humus-sulphate (calcareous) and underdeveloped mountain chestnut	7745	0,9
21	Typical and carbonated meadow-brown	41735	4,7
24	Dark and ordinary chestnut	23747	2,7
25	Partially residual salted light chestnut	46979	5,3
29	Typical gray	4988	0,6
30	Light and primitive gray	7375	0,8
34	Partly saline and saline-gray	7002	0,8
35	Washed and carbonated (tugai) meadow-forest	171138	19,4

36	Alluvial-meadow	69682	7,9
37	Meadow-swamp and swamp	3944	0,4
38	Salts (deluvial, alluvial and sopkali)	6795	0,8
43	Gravel-stone river deposits	23981	2,7
44	Bare rocks and various rocks on the surface	33533	3,8
	Total	**883491**	**100**

Up to 54% (476.1 thousand ha) of land resources are distributed in mountainous areas, 46.0% (407.4 thousand ha) in the plains and especially in the Alazan-Haftaran valley. About 30.0% (291.0 thousand hectares) of the total land fund of the region consists of mountain and forest lands. Types and subtypes of brown mountain-forest soils occupy a wider area due to their distribution area. The area of brown forest lands together with meadow mountain-forest lands is 249.1 thousand ha or 52.3% of the total mountainous lands. Types and subtypes of brown mountain-forest soils distributed in relatively limited areas are equal to 8.7% (41.5 thousand hectares) of the forest land fund of the region.

Different types and subtypes of meadow lands of subalpine and alpine meadows, distributed in the high mountain belt of the region, which is of great importance in agriculture, especially in the development of sheep breeding, cover 10.3% (120.5 thousand hectares) of mountain lands. Bare rocks and various types of rocks that form a unique natural landscape in this zone occupy about 4.0% (33.5 thousand hectares) of the land fund of the mountainous area [5].

Widespread types and subtypes of mountain-black, mountain gray-brown and mountain-chestnut soils, widely used in the development of grain, fruit, cocoon, livestock and other agricultural sectors in the region and characterized by potential fertility, account for about 7.0% of the mountain land fund. (61.6 thousand hectares). 46% (407.4 thousand hectares) of the total land resources of the region are located in the plain zone of great economic importance, and especially in the Alazan-Haftaran valley. Some of the meadow-brown, chestnut, gray, gray-brown alluvial-meadow, meadow-swamp lands spread in the area are now widely used in agriculture of the region. The rest of these lands have been exposed to the negative effects of natural and anthropogenic processes over the past period - salinization, salinization, swamping, erosion, landslides, etc. cases. As a result, lands with deteriorated general reclamation status were excluded from agricultural turnover due to loss of fertility properties.

At present, 45.7% of the total land resources of the region (403.4 thousand hectares) are involved in circulation as they are completely suitable for agriculture. 44.8% of this (180.9 thousand hectares) covers arable and reclaimed lands. The area under perennial crops reaches 10.3% (41.4 thousand hectares). Most of the agricultural lands in the region are grazing and pasture lands, accounting for about 39.8% (160.8 thousand hectares). Currently, backyard lands cultivated as arable land make up 4.7% (19.0 thousand hectares) of the total agricultural land. Forest lands cover 30.9% of the area (272.7 thousand hectares). Other lands that are considered impossible to use in agriculture cover 23.4% of the total land fund (207.4 thousand hectares).

Results and its discussion

The production of crop products in the region is mainly obtained on irrigated lands up to 105.6 thousand hectares. At present, 26.6% of agricultural lands are irrigated. Of this, 73.2% is irrigated arable land and 9.8% is perennial crops. A small part of pastures and grazing lands, ie 1.7% (1.8 thousand hectares) is irrigated.

Natural and anthropogenic processes, which have a strong impact on the formation of the total land cover in the region, have also affected the quality parameters of lands used in agriculture for a long time.

Only 14.3% (57.5 thousand hectares) of agricultural land in this area is of high quality. 39.2% of this (18.9 thousand hectares) is backyard land. The fact that a small part of the vital arable and fallow lands in the region, about 10.0% (18.0 thousand hectares) and its main mass is in the II and III quality groups, shows that the reclamation status of these lands has changed in an insufficient direction. The concentration of 40.5% of perennial arable lands in the good quality group indicates that the fertility properties of these soils are in good condition compared to arable and fallow lands. Certain signs of degradation are also observed in hayfields. In the past, arable lands with a small area had to be included in the high-quality group. However, due to the lack of proper care for hayfields, as well as other land plots, it reaches 27.2% (04, thousand hectares) in the average quality group.

Transfer dynamics have become more serious in pastures and grazing areas. Thus, 65.3% (64.1 thousand ha) of the total pasture area of about 98.2 thousand hectares was transferred to quality groups III and IV as a result of intensive exploitation of canine grazing lands. This is also reflected in the dynamics of the distribution of the quality group of summer and winter pastures. Only 4.5% of the total area of summer and winter pastures (2.9 thousand ha) was in the first quality group, and 18.8% (18.0 thousand ha) was in the second quality group. The transfer of the remaining 66.7% (41.6 thousand ha) to quality groups III and IV indicates a strong process of degradation in pasture lands. The dynamics of transfers in the quality group of agricultural areas in different regions of the region is characterized by instability. Transfers are stronger and more intensive, especially in pastures. Sheki is located at an altitude of 500-850 m above sea level. The height of snowy peaks of the Main Caucasus Range reaches 3000-3500 m in some places. Jurassic, Cretaceous, Neogene and Anthropogenic sediments are spread in the mountains. Sheki is located in the north-west of Azerbaijan, on the southern slope of the Greater Caucasus Mountains, at an altitude of 632 m above sea level. It has abundant water resources, normal moisture balance, fertile soils and rich forest cover.

Brown mountain forest, brown mountain forest, meadow forest, gray-brown soils are widespread. Oak, beech and walnut trees predominate in the forests. The fauna is rich [3]. As a result of charming nature, unique historical and architectural monuments, developed craftsmanship, protection of rich historical and cultural heritage, Sheki has become an important tourist region of Azerbaijan. According to the research, starting from the watershed of the Greater Caucasus tribe in the region, in the areas included in the Alazan-Haftaran valley and the northern slope of the Sheki plateau, mountain meadow-grass, mountain meadow-forest-like, mountain meadow-forest, mountain forest-brown, mountain forest, alluvial-meadow, meadow-swamp, mountain black and mountain chestnut soil types have been identified. The mountain-meadow lands cover a relatively large area in the north-eastern part of the region in the border zone with the Gabala region and extend to the west in the form of a strip cut by river valleys to the territory of Bash Dashagil village [8]. Mountain-meadow lands cover an area of 12,000 ha between 2000-3000 m above sea level in the watershed and adjacent alpine and subalpine zones.

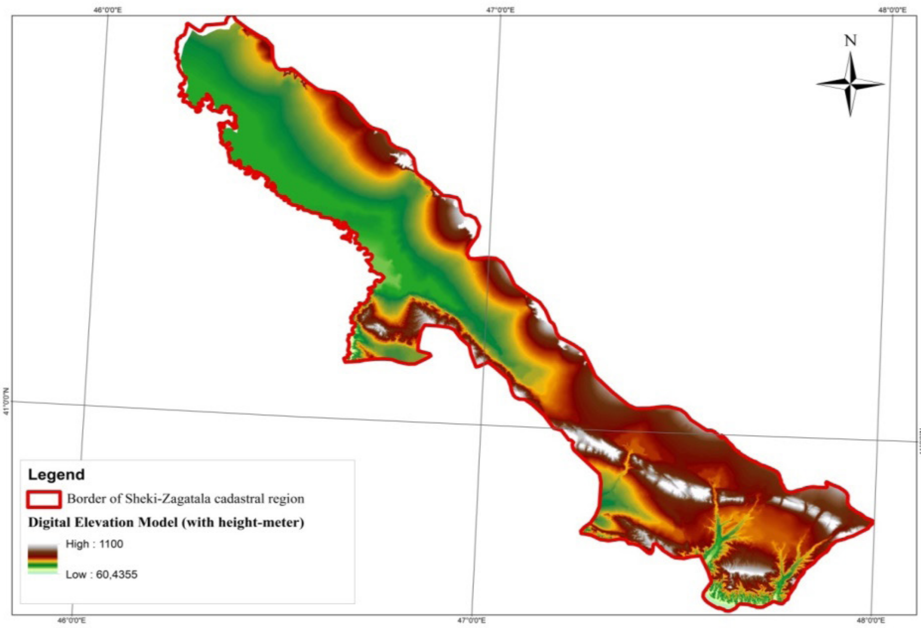
The area of mountain meadow-forest lands is up to 3,000 ha, formed at an altitude of 1800–2100 m above sea level in the upper border of the forest and inter-forested steppe areas, under sparse beech forests and subalpine meadows on clay products.

Mountain brown-forest soils are spread along the Dashagilchay, Agligchay and Galachay basins, between the heights of 1100 m to 2200 m above sea level and cover an area of 26,000 hectares. These soils are characterized by a dark and broad humus layer of thick forest floor, good water collection capacity and high humus content (8.0 - 15.0%), heavy clayey mechanical composition and richness of ash elements. Mountain forest-brown soils in the surrounding areas of Calut, Khalkhal and Khachmaz villages at an altitude of 500-1200 m above sea level, in relatively temperate and dry climates, under oak forests, shrubs and grasses, separate spots, strips and stripes on carbonate clay erosion products spread in the form of [1].

In the territory of Oguz region, in a wide alluvial plain cut by many branches of Dashagilchay, Khalkhalchay, Alijanchay, Agchay, included in the eastern end of Alazan-Haftaran valley, Bujag, Gumlag, Karimli, Padar, Xinjiang, Mollali and others. Alluvial-meadow lands are spread around the villages, and meadow-swamp lands are spread in small areas in the territory of Bayan and Gumlag villages. Part of the alluvial meadow-forest lands is under Tugay forests, and part of it is used for low-yielding hay and irrigated vegetable crops. Alluvial meadow-forest, alluvial-meadow and meadow-swamp soils are relatively close to each other by forming a complex according to climatic indicators, relief conditions, nature of soil-forming rocks, hydrogeological condition and usage characteristics. grass plantings, etc. They are suitable for the development of farms. The southern and south-eastern part of the region covers the weakly sloping northern slope of the Sheki plateau. In the territory of Yagublu, Yenikend, Boyuk Soyudlu villages and on the northern slope of the Dry Kahriz tribe, along with the usual hardened and carbonated, mountain-black soils, dark chestnut and chestnut soils are also spread in small areas. Mountain-black and chestnut soils are suitable for irrigation and drip cultivation and are characterized by high productivity. 36.5% of the total land area of the region, ie 44,492 hectares are suitable for agricultural areas. 18,183 hectares of land, or 15.8%, are irrigated. 46.6% of the total land fund in the district belongs to the state property, 8.1% to the municipal property, 45.2% to the private property. 15.8% of the total land fund is suitable for planting [2].

Conclusıons

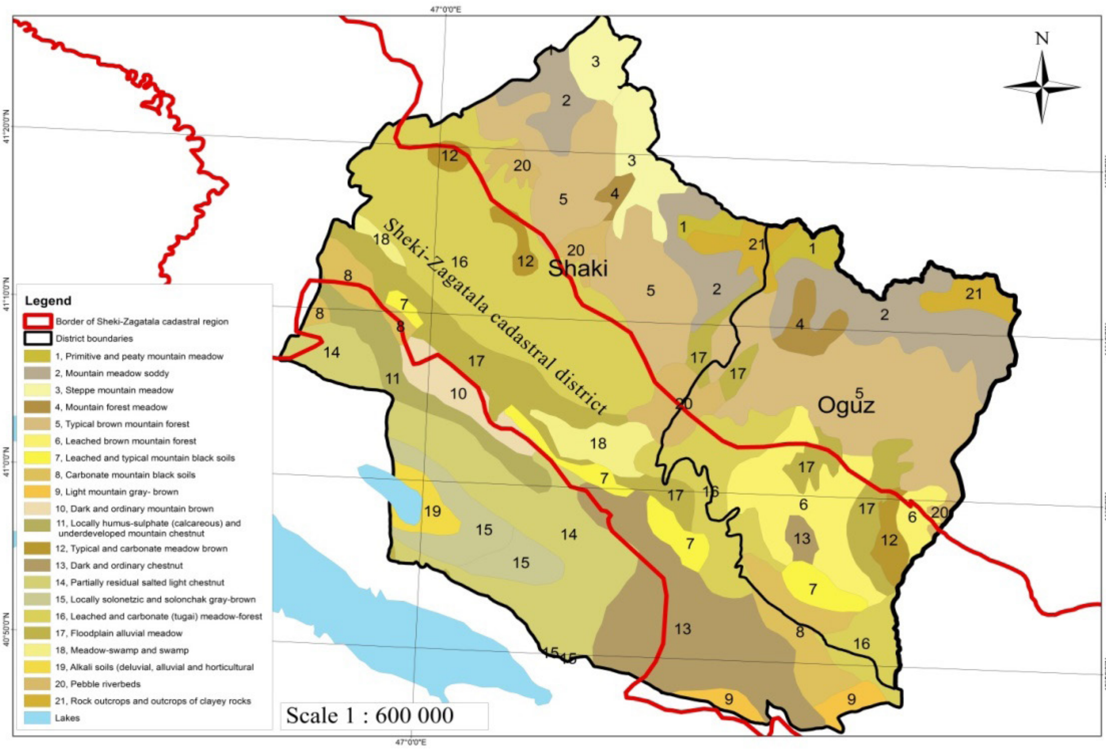
On the basis of GIS, the initial version of the elevation model (demin) of the area, the land map was prepared. The very complex and sharp change in the relief conditions in the area along the vertical belt has led to the formation of different climate types here. Thus, all climatic elements are unevenly distributed in the area due to the increase in altitude from the south-west to the north-east of the semi-desert, dry steppe cold and mountain tundra climate types. According to the climatic indicators of Zagatala meteorological station in the north-west of the area, the average annual temperature is 12.50. The cold season of the year is characterized by 2.10 in winter and 22.90 in hot summer. In the cold season, the temperature does not exceed 5.60, while in the warm season it reaches 19.40. According to the observations of the Sheki meteorological station in the central part of the area, these figures are slightly different. Thus, the average annual temperature is 0.50 in winter and 0.20-0.40 in summer [7]. In the city of Gabala, which ends in the east, the corresponding figures are between 0.20 and 21.00, and even the difference in average temperature is 1.90 lower than in Zagatala. The amount of precipitation in the area and the distribution regime are quite different. Different vegetation is formed in the zones depending on the relief and climatic conditions. Acinohur steppe, located in the south of the Alazan-Haftaran valley, has dry steppe and semi-desert vegetation and xerophytic shrubs. We have compiled a digital territorial model map of the Shek-Zagatala cadastral region. Based on this, it was determined that the maximum height of the study area is 1,100 meters, and the minimum height is 60 meters. We have also developed a trend map based on a digital area model. Based on this, it can be said that the lowest indicator in the study area was 0, the highest was 740.



Soil types and subtypes in the territory of Sheki and Oguz districts are given below.

1. Primary and peat meadow
2. Grassy mountain-meadow
3. Steppe mountain-meadow
4. Meadow mountain-forest
5. Typical brown mountain-forest
6. Washed brown mountain-forest
7. Washed and typical mountain-black
8. Carbonate mountain black

9. Light mountain-gray brown
10. Dark and ordinary effortless
11. Partially rotten - sulfate and underdeveloped mountain chestnut
12. Typical and carbonated meadow brown
13. Dark and ordinary chestnut
14. Partially humus-sulphate (lime) and immature mountain chestnut
15. Partially saline and saline grayish-gray and gray-brown
16. Washed and carbonated (tugai) meadow forest
17. Subasar alluvial meadow
18. Meadow swamp and swamp
19. Salts (dulluvial, alluvial and sopkali)
20. Pebble river deposits
21. Bare rocks and exposed clayey rocks



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Sawflies (Hymenoptera: Symphyta) of Kintrishi National Park, south-west Georgia (Sakartvelo)

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A B S T R A C T

Sixty-five sawfly species have beenwere identified from a total of 1,703 specimens collected in Kintrishi National Park at three different altitudes using Malaise traps. Sixteen genera and 42 species were recorded for the first time in Georgia (Sakartvelo). The seasonal dynamics and diversity of sawfly community and vertical zoogeographical distribution of sawflies are also analysed and discussed.

***Key words*:** Hymenoptera, Symphyta, Kintrishi National Park, Sakartvelo, ecology, nature conservation

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Introduction

Kintrishi National Park (KNP) is located in Achara, in the southwestern part of Sakartvelo (Georgia), Kobuleti district, 55 km from Batumi and 360 kilometers km from Tbilisi, in Kobuleti municipality, around the valley of the Kintrishi River, between the villages Tskhemvana and Khino, at an altitude between 300 and 2 500 m above sea level (Fig.1). The protected area is 13,514 hectares. Since 1959, the territory of Kintrishi had the status of a nature reserve, and in 2019, it was declared a national park [1].

The Kintrishi NP is located between the Black Sea and the Achara-Imereti Mountains. These mountains trap moist air from the sea and create a very humid climate for Kintrish. The annual rainfall is almost 3,000 mm. The average temperature in August is +24 degrees, and +4 degrees in January. The mountainous terrain of the reserve is criss-crossed by deep valleys. The main water vein of the reserve - the Kintrishi River - rises in the Khino Mountain and flows into the Black Sea. Its total length is 45 kilometres. The other main watercourses of the area are: Kehnara, Peranga, Mamedagi, Didgele, Misanatisgele, which has a beautiful waterfall 30 metres high, and the rivers Bolkvadzeebisgele and Chrdila, the latter with a two-tired waterfall 70 metres high. In the high mountains, at an altitude of 2200 metres, there are two small lakes, namely the Tbikeli (Neck Lake) and Sidzerdzali (Son-in-law and Daugter-in-law), whose area is about 1.5 hectares.

The ponto-mediterran vegetation belt (500 m) is replaced by oak-hornbeam (500-1,000 m) and oak (1,000-2,000 m) belts. Above these belts, subalpine birch forests (2,000-2,200 m) and alpine meadows (2,200-2,600 m) take place.

The unique botanical values of this area are the Colchian relict forests including sweet chestnuts (*Castanea sativa*), Colchian buxus trees (*Buxus* *colchica*), oaks (*Quercus* spp.), yews (*Taxus baccata*) and conifs. The age of some Buxus trees exceeds 300 years. These forests provide habitat for endemic azaleas (*Rhododendron ponticum* and *Rhodondendron caucasicum*).

The date of the description of the first sawfly species from Georgia is uncertain. In the 19th century, authors simply wrote: ″Patria Caucasus" or ″Transcaucasia" or ″Rossia: Caucasus″. Without precise locality information, it is difficult to decide wether these species were described from the Caucasian part of Russia, from Georgia, Armenia or Azerbaijan [2-6]. The first Georgian checklist was published by Radde [7], keys for sawflies and horntails (Symphyta) were compiled by Andguladze [8] and Dadurian [9]. So far, 105 species of Symphyta are listed in the Georgian Biodiversity Database [10], but these data need to be carefully checked and corrected. In fact, the estimated actual species richness of Symphyta is probably 4 times greater.

Methods and material

Three Malaise traps (Fig.2) were used to sample sawflies and were in operation from 23 April to 3 November 2018. The traps were checked every 12-17 days and insects were removed . The material was preserved in alcohol, later, in 2021, the sawflies were mounted and genitalia were dissected for further identification.

The following keys were used for species identification: Zhelochovtsev's work [11] on the sawflies of the European part of the former USSR, Lacourt´s manual [12] on the identification of European sawflies, Robert Benson´s monograph [13] on the Turkish sawfly fauna, Gussakovsky's monographs [14,15] on the Symphyta of the former USSR and the latest monograph on Czech and Slovakian sawflies [16]. We also used some recent revisions and works to make the identifications and biological data even more accurate [17-26].

Voucher specimens are deposited in the entomological collection of the Institute of Entomology of the Agricultural University of Georgia.

For the discussion of the distribution of sawflies, we have consulted the book by Roller and Haris entitled Sawflies of the Carpathian Basin, History and Current Research [27], the most recent European checklist of species [28] and the monograph by Sundukov on the sawflies of Russia [29], supplemented by other faunistic records [29-35].

The nomenclature used in this article, follows the latest monograph of the European sawflies [12] with special attention to the subfamily Nematinae and corrects the conclusions of Prous et al. [36].

For above reasons, if only the name „Caucasus" was given as the distribution, we have considered these species as not previously recorded from Georgia and marked them as new country records. New country records are indicated with an asterisk.

The higher classification of sawflies used in this paper follows the Hymenoptera section of Fauna Europaea [37].

Models for flight activity and dynamics of biodiversity, indices of biodiversity and dominance were interpreted and applied following the work of Daly et al. [38], Nedorezov [39] and Young [40]. In classifying the biogeographical region, we followed the latest publication of the European Environment Agency [41] entitled Biogeographical regions in Europe.

List of sampling sites (Fig.1).

Zeraboseli: Kintrishi River: N 41°44'13.7364, E 41°58'45.1668, altitude: 404 m.

Khinotsminda: Cherulisghele River: N 41°44'38.8824, E 42°5'0.2904, altitude: 1264 m.

Khinotsminda: Khinotsminda Monastery: N 41°43'45.9768, E 42°4'38.8812, altitude: 1020 m.

Results and Discussion

List of species

Family – Argidae

Genus *Arge* Schrank, 1802

1. *Arge cyanocrocea* (Forster, 1771)*(*= first record for Georgia)

Material examined: Zeraboseli: Kintrishi River, 23. 04. – 05. 05. 2018, 2 males, 05. 05. – 20. 05. 2018, 1 female; Khinotsminda: Cherulisghele River, 20. 04. – 05. 05. 2018, 1 female, 1 male, Khinotsminda Monastery, 27. 07. – 10. 08. 2018, 1 female. (All collected individuals belong to the colour variety formerly classified as *Arge syriaca* (Mocsáry, 1880)). Common, West Palaearctic species. Known host plants: *Rubus idaeus* and

Sanguisorba officinalis.

Genus *Sterictiphora* Billberg, 1820*

2. *Sterictiphora angelicae* (Panzer, 1799)*

Material examined: Zeraboseli: Kintrishi River, 23. 04. – 05. 05. 2018, 1 male. Frequent. Larva on *Prunus spinosa* and *Rubus* spp. West Palaearctic.

Family – Cephidae

Genus *Janus* Stephens, 1829

3. *Janus cynosbati* (Linné, 1758)*

Material examined: Khinotsminda Monastery, 20. 04. – 05. 05. 2018, 3 females. Sporadic, West Palaerarctic species, larva in shots of *Quercus* spp.

Family - Pamphiliidae

Genus *Onycholyda* Takeuchi, 1938

4. *Onycholyda trigaria* (Konow, 1897)

Material examined: Zeraboseli: Kintrishi River, 23. 04. – 05. 05. 2018, 1 male, 05. 05. – 20. 05. 2018, 1 female, 1 male, 19. 05. – 01. 06. 2018, 5 males, 01. 06. – 15. 06. 2018, 2 males; Khinotsminda: Cherulisghele River, 01. 06. – 15. 06. 2018, 1 female, 3 males. Frequent, Ponto-Caspian-Iranian species. Hostplant unknown.

Genus Pamphilius Latreille, 1803

5. *Pamphilius pugnax* Konow, 1897

Material examined: Zeraboseli: Kintrishi River, 23. 04. – 05. 05. 2018, 1 male. Sporadic, Ponto-Caspian species. Hostplant unknown.

Family - Tenthredinidae

Genus *Allantus* Panzer, 1801

6. *Allantus* (Emphytus) *cinctus* (Linné, 1758)

Material examined: Zeraboseli: Kintrishi River, 23. 04. – 05. 05. 2018, 20 females, 52 males, 05. 05. – 20. 05. 2018, 11 females, 39 males, 19. 05. – 01. 06. 2018, 11 females, 19 males, 01. 06. – 15. 06. 2018, 2 females, 14 males, 15. 06. – 29. 06. 2018, 2 females, 15 males, 29. 06. – 13. 07. 2018, 6 males, 13. 07. – 27. 07. 2018, 6 females, 60 males, 27. 07. – 10. 08. 2018, 2 females, 60 males, 10. 08. – 24. 08. 2018, 1 female, 32 males, 24. 08. – 07. 09. 2018, 6 females, 41 males, 21. 09. – 05. 10. 2018, 1 female, 19. 10. – 03. 11. 2018, 1 female; Khinotsminda: Cherulisghele River, 20. 04. – 05. 05. 2018, 1 female, 10 males, 05. 05. – 20. 05. 2018, 4 females, 9 males, 01. 06. – 15. 06. 2018, 3 females, 9 males; Khinotsminda Monastery, 20. 04. – 05. 05. 2018, 16 females, 3 males, 05. 05. – 20. 05. 2018, 5 females, 19. 05. – 01. 06. 2018. 6 females, 1 male, 01. 06. – 15. 06. 2018. 2 females, 1 male, 15. 06. – 29. 06. 2018, 2 females, 5 males, 29. 06. – 13. 07. 2018, 2 females, 27. 07. – 10. 08. 2018, 2 females, 5 males, 24. 08. – 07. 09. 2018, 2 females, 07. 09. – 21. 09. 2018, 1 female. Common. Host plants: *Rosa* and *Fragaria* spp. Holarctic.

Genus *Ametastegia* Costa, 1882

7. *Ametastegia* (Ametastegia) *equiseti* (Fallén, 1808)

Material examined: Zeraboseli: Kintrishi River, 23. 04. – 05. 05. 2018, 2 females, 4 males, 05. 05. – 20. 05. 2018, 1 male, 19. 05. – 01. 06. 2018, 1 male, 01. 06. – 15. 06. 2018, 1 male, 15. 06. – 29. 06. 2018, 1 female, 1 male; Khinotsminda: Cherulisghele River, 20. 04. – 05. 05. 2018, 1 female, 05. 05. – 20. 05. 2018, 1 male. Frequent. Larva on *Chenopodium album*, *Lythrum salicaria*, *Polygonum persicaria* and *Rumex acetosella*. Holarctic.

8. *Ametastegia* (Protemphytus) *carpini* (Hartig, 1837)*

Material examined: Zeraboseli: Kintrishi River, 23. 04. – 05. 05. 2018, 1 female, 15. 06. – 29. 06. 2018, 1 female, 13. 07. – 27. 07. 2018, 2 females. Frequent. Holarctic. Host plants: *Geranium* spp.

9. *Ametastegia* (Protemphytus) *pallipes* (Spinola, 1808)*

Material examined: Zeraboseli: Kintrishi River, 23. 04. – 05. 05. 2018, 1 male, 05. 05. – 20. 05. 2018, 1 female, 1 male, 01. 06. – 15. 06. 2018, 1 female, 13. 07. – 27. 07. 2018, 1 female, 27. 07. – 10. 08. 2018, 1 female, 1 male. Frequent. Host plants: *Viola* spp. Holarctic.

Genus *Aneugmenus* Hartig, 1837

10. *Aneugmenus coronatus* (Klug, 1818)

Material examined: Zeraboseli: Kintrishi River, 23. 04. – 05. 05. 2018, 3 females, 05. 05. – 20. 05. 2018, 3 females,19. 05. – 01. 06. 2018, 3 females, 01. 06. – 15. 06. 2018, 7 females, 15. 06. – 29. 06. 2018, 2 females, 29. 06. – 13. 07. 2018, 1 female, 13. 07. – 27. 07. 2018, 2 females, 27. 07. – 10. 08. 2018, 3 females, 10. 08. – 24. 08. 2018,1 female; Khinotsminda: Cherulisghele River, 01. 06. – 15. 06. 2018, 3 females; Khinotsminda Monastery, 20. 04. – 05. 05. 2018, 1 female, 05. 05. – 20. 05. 2018, 1 female, 15. 06. – 29. 06. 2018, 3 females, 29. 06. – 13. 07. 2018, 1 female, 27. 07. – 10. 08. 2018, 4 females. Sporadic, Palaearctic species. Larva on *Dryopteris filix-mas*, *Aspidium* sp., *Athyrium filix-femina* and *Pteridium aquilinum*.

Genus *Athalia* Leach, 1817

11. *Athalia circularis* (Klug, 1815)

Material examined: Zeraboseli: Kintrishi River, 23. 04. – 05. 05. 2018, 4 males, 05. 05. – 20. 05. 2018, 4 males, 19. 05. – 01. 06. 2018, 1 male, 24. 08. – 07. 09. 2018, 1 female, 2 males, 13. 07. – 27. 07. 2018, 1 female, 1 male; Khinotsminda: Cherulisghele River, 20. 04. – 05. 05. 2018, 1 male; Khinotsminda Monastery, 05. 05. – 20. 05. 2018, 1 male, 24. 08. – 07. 09. 2018, 1 female. Frequent. Host plants: *Arctium lappa*, *Ajuga reptans*, *Veronica beccabunga*, *V. longifolia*, *V. officinalis*, *Alliaria petiolata*, *Glechoma hederacea*, *Melampyrum*, *Capsella* and *Lycopus* spp. Palaearctic.

12. *Athalia cordata* Serville, 1823

Material examined: Zeraboseli: Kintrishi River, 19. 10. – 03. 11. 2018, 1 female. Common. Larva on *Misopates orontinum*, *Antirrhinum majus*, *Ajuga reptans*, *Teucrium scorodonia* and *Plantago* spp. West Palaearctic.

13. *Athalia liberta* (Klug, 1815)

Material examined: Zeraboseli: Kintrishi River, 23. 04. – 05. 05. 2018, 4 males, 29. 06. – 13. 07. 2018 , 1 male, 13. 07. – 27. 07. 2018, 2 females, 2 males, 27. 07. – 10. 08. 2018, 1 female, 1 male, 29. 06. – 13. 07. 2018, 1 female, 10. 08. – 24. 08. 2018, 2 females, 24. 08. – 07. 09. 2018, 2 females; Khinotsminda Monastery, 20. 04. – 05. 05. 2018, 1 male, 19. 05. – 01. 06. 2018, 2 females, 24. 08. – 07. 09. 2018, 3 females. Frequent, West Palaearctic species. Feeding on *Alliaria petiolata*, *Arabidopsis thaliana*, *Cardamine hirsuta* and *Sisymbrium officinale*.

14. *Athalia lugens* (Klug, 1815)

Material examined: Zeraboseli: Kintrishi River, 23. 04. – 05. 05. 2018, 4 males, 05. 05. – 20. 05. 2018, 1 male, 19. 05. – 01. 06. 2018, 1 male, 01. 06. – 15. 06. 2018, 2 males, 15. 06. – 29. 06. 2018, 1 male, 29. 06. – 13. 07. 2018, 2 females, 1 male, 13. 07. – 27. 07. 2018, 1 female, 1 male, 27. 07. – 10. 08. 2018, 2 females, 24. 08. – 07. 09. 2018, 1 female, 21. 09. – 05. 10. 2018, 1 female, 19. 10. – 03. 11. 2018, 1 female; Khinotsminda: Cherulisghele River, 01. 06. – 15. 06. 2018, 1 female. Frequent Palaearctic species. Hostplants: *Raphanus* spp., *Lepidium sativum*, *Cardamine* spp., *Brassica* spp., *Cruciferae*.

Genus *Birka* Malaise, 1944*

15. *Birka* (Birka) *catellata* (Konow, 1900)*

Material examined: Zeraboseli: Kintrishi River, 23. 04. – 05. 05. 2018, 4 females, 7 males, 05. 05. – 20. 05. 2018, 6 females, 15 males, 19. 05. – 01. 06. 2018, 2 females, 17 males, 01. 06. – 15. 06. 2018, 5 females, 20 males, 15. 06. – 29. 06. 2018, 1 female, 15. 06. – 29. 06. 2018 , 24 males, 13. 07. – 27. 07. 2018, 10 females, 14 males, 27. 07. – 10. 08. 2018, 13 males, 10. 08. – 24. 08. 2018, 3 females, 1 male, 24. 08. – 07. 09. 2018, 1 female; Khinotsminda: Cherulisghele River, 20. 04. – 05. 05. 2018, 1 male, 05. 05. – 20. 05. 2018, 1 male, 01. 06. – 15. 06. 2018, 5 males; Khinotsminda Monastery, 20. 04. – 05. 05. 2018, 1 female, 15. 06. – 29. 06. 2018, 1 female, 27. 07. – 10. 08. 2018, 1 female, 27. 07. – 10. 08. 2018, 3 males. Ponto-Caspian and Turanian. Common species. Hostplant unknown.

16. *Birka* (Birka) *cinereipes* (Klug, 1816)*

Material examined: Zeraboseli: Kintrishi River, 05. 05. – 20. 05. 2018, 1 male, 15. 06. – 29. 06. 2018, 2 males. Sporadic. Host plants: *Myosotis* spp. Palaearctic.

Genus *Caliroa* Costa, 1859

17. *Caliroa cothurnata* (Serville, 1823)*

Material examined: Zeraboseli: Kintrishi River, 05. 05. – 20. 05. 2018, 2 females, 19. 05. – 01. 06. 2018, 1 female, 01. 06. – 15. 06. 2018, 1 female, 13. 07. – 29. 07. 2018, 1 female. West Palaearctic. Frequent. Larva on *Quercus* spp.

18. *Caliroa tremulae* Chevin, 1974*

Material examined: Zeraboseli: Kintrishi River, 05. 05. – 20. 05. 2018, 1 male, 01. 06. – 15. 06. 2018, 1 female, 24. 08. – 07. 09. 2018, 2 females. Sporadic. Hostplant: *Populus tremula*. West Palaearctic.

19. *Caliroa varipes* (Klug, 1816)*

Material examined: Zeraboseli: Kintrishi River, 23. 04. – 05. 05. 2018, 1 female. Sporadic. Palaearctic. Larva on *Quercus*.

Genus *Cladius* Illiger, 1807

20. *Cladius pectinicornis* (Geoffroy, 1785)

Material examined: Zeraboseli: Kintrishi River, 23. 04. – 05. 05. 2018, 1 male, 05. 05. – 20. 05. 2018, 1 female, 19. 05. – 01. 06. 2018, 1 male, 01. 06. – 15. 06. 2018, 1 female, 1 male, 29. 06. – 13. 07. 2018, 1 male, 24. 08. – 07. 09. 2018, 1 male; Khinotsminda Monastery, 27. 07. – 10. 08. 2018, 1 female. Common. Host plants: *Alchemilla*, *Filipendula*, *Fragaria*, *Potentilla*, *Sanguisorba*, *Rosa* and *Rubus* spp. Holarctic.

Genus *Claremontia* Rohwer, 1909*

21. *Claremontia alternipes* (Klug, 1816)*

Material examined: Zeraboseli: Kintrishi River, 23. 04. – 05. 05. 2018, 4 females, 1 male, 05. 05. –

20. 05. 2018, 1 female; Khinotsminda Monastery, 20. 04. – 05. 05. 2018, 4 females. Sporadic. Host plant: *Rubus idaeus*. West Palaearctic.

Genus *Craesus* Leach, 1817*

22. *Craesus brischkei* (Zaddach, 1876)*

Material examined: Zeraboseli: Kintrishi River, 13. 07. – 29. 07. 2018, 1 female. Sporadic. Larva on *Carpinus betulus* and *Corylus avellana*. West Palaearctic.

Genus *Dolerus* Panzer, 1801

23. *Dolerus* (Dicrodolerus) *vestigialis* (Klug, 1818)*

Material examined: Zeraboseli: Kintrishi River, 23. 04. – 05. 05. 2018, 2 females; Khinotsminda: Cherulisghele River, 20. 04. – 05. 05. 2018, 1 female. Common. Host plants: *Equisetum palustre*, *E. sylvaticum*, *E. arvense* and *E. pratense*. Palaearctic.

Genus *Empria* Lepeletier & Serville, 1828

24. *Empria longicornis* (Thomson, 1871)*

Material examined: Zeraboseli: Kintrishi River, 23. 04. – 05. 05. 2018, 1 male, 05. 05. – 20. 05. 2018, 1 female, 1 male; Khinotsminda Monastery, 20. 04. – 05. 05. 2018, 2 males, 4 females, 05. 05. – 20. 05. 2018, 4 females, 19. 05. – 01. 06. 2018, 1 female, 01. 06. – 15. 06. 2018, 1 female, 15. 06. – 29. 06. 2018, 1 female. Frequent, West Palaearctic species. Larva on *Rubus idaeus*.

25. *Empria testaceipes* (Konow, 1896)*

Material examined: Zeraboseli: Kintrishi River, 23. 04. – 05. 05. 2018, 1 male. Sporadic West Palaearctic species. Larva on *Sanguisorba officinalis*.

Genus *Eriocampa* Hartig, 1837

26. *Eriocampa umbratica* (Klug, 1816)

Material examined: Zeraboseli: Kintrishi River, 23. 04. – 05. 05. 2018, 6 females, 55 males, 05. 05. – 20. 05. 2018, 15 males, 19. 05. – 01. 06. 2018, 1 male, 01. 06. – 15. 06. 2018, 1 female, 2 males; Khinotsminda: Cherulisghele River, 20. 04. – 05. 05. 2018, 10 males; Khinotsminda Monastery, 27. 07. – 10. 08. 2018, 1 female. Frequent on *Alnus glutinosa* and *A. incana*. West Palaearctic.

Genus *Eurhadinoceraea* Enslin, 1920*

27. *Eurhadinoceraea fulviventris* (Scopoli, 1763)*

Material examined: Zeraboseli: Kintrishi River, 23. 04. – 05. 05. 2018, 2 females, 05. 05. – 20. 05. 2018, 1 female, 19. 05. – 01. 06. 2018, 2 females, 57 males, 01. 06. – 15. 06. 2018, 4 females, 21 males; Khinotsminda: Cherulisghele River, 20. 04. – 05. 05. 2018, 3 males, 05. 05. – 20. 05. 2018, 2 males, 01. 06. – 15. 06. 2018, 5 males; Khinotsminda Monastery, 20. 04. – 05. 05. 2018, 2 females, 01. 06. – 15. 06. 2018, 1 male, 27. 07. – 10. 08. 2018, 2 females, 4 males. Common. Hostplant unknown. Southern part of the Palaearctic region.

Genus *Eutomostethus* Enslin, 1914

28. *Eutomostethus vopiscus* (Konow, 1899)* (Fig.3A)

Material examined: Zeraboseli: Kintrishi River, 23. 04. – 05. 05. 2018, 2 females, 9 males, 05. 05. – 20. 05. 2018, 7 females, 8 males, 01. 06. – 15. 06. 2018, 8 females, 2 males, 29. 06. – 13. 07. 2018, 2 males, 13. 07. – 27. 07. 2018, 1 male, 27. 07. – 10. 08. 2018, 2 females, 10. 08. – 24. 08. 2018, 2 females, 1 male; Khinotsminda: Cherulisghele River, 01. 06. – 15. 06. 2018, 1 female; Khinotsminda Monastery, 20. 04. – 05. 05. 2018, 3 females, 05. 05. – 20. 05. 2018, 2 females, 19. 05. – 01. 06. 2018, 1 female, 01. 06. – 15. 06. 2018, 2 females, 15. 06. – 29. 06. 2018, 2 females, 27. 07. – 10. 08. 2018, 1 female. Common. Hostplants: Poaceae. Ponto-Caspian subspecies.

29. *Eutomostethus luteiventris* (Klug, 1816)*

Material examined: Zeraboseli: Kintrishi River, 05. 05. – 20. 05. 2018, 1 female. Frequent. Larva on *Juncus effusus*. West Palaearctic, introduced to North America.

Genus *Halidamia* Benson, 1939

30. *Halidamia affinis* (Fallén, 1807)

Material examined: Zeraboseli: Kintrishi River, 19. 05. – 01. 06. 2018, 5 females, 01. 06. – 15. 06. 2018, 3 females; Khinotsminda Monastery, 27. 07. – 10. 08. 2018, 1 female. Frequent. Host plants: *Galium aparine*, *G.odoratum* and *G. molugo*. West Palaearctic, introduced to North America.

Genus *Heterarthrus* Stephens, 1835

31. *Heterarthrus vagans* (Fallén, 1808)*

Material examined: Zeraboseli: Kintrishi River, 05. 05. – 20. 05. 2018, 1 female, 19. 05. – 01. 06. 2018, 2 females, 15. 06. – 29. 06. 2018, 1 female, 29. 06. – 13. 07. 2018, 1 male, 13. 07. – 27. 07. 2018, 3 females, 27. 07. – 10. 08. 2018, 4 females, 10. 08. – 24. 08. 2018, 1 male, 24. 08. – 07. 09. 2018, 1 female, 07. 09. – 21. 09. 2018, 1 female, 21. 09. – 05. 10. 2018, 1 female. Sporadic, larva on *Alnus* spp. Holarctic.

Genus *Hemichroa* Stephens, 1835*

32. *Hemichroa australis* (Serville, 1823)*

Material examined: Khinotsminda: Cherulisghele River, 05. 05. – 20. 05. 2018, 1 female. Hostplants: *Alnus glutinosa* and *Betula* spp. Sporadic. Palaearctic.

Genus *Macrophya* Dahlbom, 1835

33. *Macrophya* (Macrophya) *albicincta* (Schrank, 1776)

Material examined: Zeraboseli: Kintrishi River, 23. 04. – 05. 05. 2018, 18 females, 57 males, 05. 05. – 20. 05. 2018, 2 females, 13 males, 19. 05. – 01. 06. 2018, 4 males, 01. 06. – 15. 06. 2018, 2 females, 1 male; Khinotsminda: Cherulisghele River, 20. 04. – 05. 05. 2018, 1 female, 12 males, 05. 05. – 20. 05. 2018, 1 female, 7 males, 01. 06. – 15. 06. 2018, 2 males; Khinotsminda Monastery, 20. 04. – 05. 05. 2018, 1 female, 01. 06. – 15. 06. 2018, 1 female. Common. Host plants: *Sambucus ebulus*, *S. nigra*, *S. racemosa*, *Valeriana officinalis* and *Viburnum opalus*. Palaearctic.

34. *Macrophya* (Macrophya) *caucasicola* (Muche, 1969)* (Fig.3B)

Material examined: Zeraboseli: Kintrishi River, 23. 04. – 05. 05. 2018, 5 males, 05. 05. – 20. 05. 2018, 2 females, 32 males, 19. 05. – 01. 06. 2018, 4 females, 4 males; Khinotsminda: Cherulisghele River, 05. 05. – 20. 05. 2018, 2 males; Khinotsminda Monastery, 05. 05. – 20. 05. 2018, 2 females, 19. 05. – 01. 06. 2018, 2 females, 01. 06. – 15. 06. 2018, 1 female, 15. 06. – 29. 06. 2018, 1 female. Frequent. Ponto-Caspian. Hostplant unknown.

35. *Macrophya* (Macrophya) *postica* (Brullé, 1832)

Material examined: Zeraboseli: Kintrishi River, 19. 05. – 01. 06. 2018, 1 male. Frequent. Hostplant unknown. West Palaearctic.

36. *Macrophya* (Macrophya) *sanguinolenta* (Gmelin, 1790):

Material examined: Zeraboseli: Kintrishi River, 23. 04. – 05. 05. 2018, 3 males, 01. 06. – 15. 06. 2018, 2 males; Khinotsminda: Cherulisghele River, 05. 05. – 20. 05. 2018, 2 males, Khinotsminda Monastery, 20. 04. – 05. 05. 2018, 1 male. Frequent, Palaearctic species. Larva on *Galenopsis*, *Senecio* and *Veronica*.

Genus *Metallus* Forbes, 1885

37. *Metallus beckeri* (Konow, 1904)

Material examined: Zeraboseli: Kintrishi River, 15. 06. – 29. 06. 2018, 1 female, 29. 06. – 13. 07. 2018, 1 female, 13. 07. – 27. 07. 2018, 1 female, 27. 07. – 10. 08. 2018,1 female, 10. 08. – 24. 08. 2018, 1 female, Khinotsminda Monastery, 19. 05. – 01. 06. 2018, 1 female, 15. 06. – 29. 06. 2018, 1 female, 24. 08. – 07. 09. 2018, 2 females. Frequent, Ponto-Caspian-Persian species. Hostplant unknown.

38. *Metallus lanceolatus* (Thomson, 1870)*

Material examined: Zeraboseli: Kintrishi River, 13. 07. – 27. 07. 2018, 1 female, 10. 08. – 24. 08. 2018, 1 female. Sporadic. Palaearctic, introduced to USA. Larva inside the leaves of *Geum urbanum* and *G. rivale*.

39. *Metallus pumilus* (Klug, 1816)*

Material examined: Zeraboseli: Kintrishi River, 23. 04. – 05. 05. 2018, 7 males, 05. 05. – 20. 05. 2018, 7 males, 19. 05. – 01. 06. 2018, 11 males, 01. 06. – 15. 06. 2018, 25 males, 15. 06. – 29. 06. 2018, 19 males, 29. 06. – 13. 07. 2018, 4 males, 13. 07. – 27. 07. 2018, 16 males, 27. 07. – 10. 08. 2018, 12 males, 1 female, 10. 08. – 24. 08. 2018, 3 males, 24. 08. – 07. 09. 2018, 6 males, 07. 09. – 21. 09. 2018, 1 male, 21. 09. – 05. 10. 2018, 3 males, 19. 10. – 03. 11. 2018, 1 female; Khinotsminda: Cherulisghele River, 01. 06. – 15. 06. 2018, 2 males; Khinotsminda Monastery, 20. 04. – 05. 05. 2018, 1 male, 27. 07. – 10. 08. 2018, 6 males. Common Palaearctic species. Larva inside the leaves of *Rubus caesius* and *Rubus idaeus*.

Genus *Monsoma* MacGillivray, 1908*

40. *Monsoma pulveratum* (Retzius, 1783)*

Material examined: Zeraboseli: Kintrishi River, 23. 04. – 05. 05. 2018, 1 female, 4 males. Frequent. Holarctic. Hostplants: *Alnus glutinosa* and *Alnus incana*.

Genus *Nematinus* Rohwer, 1911*

41. *Nematinus steini* Blank, 1998*

Material examined: Zeraboseli: Kintrishi River, 23. 04. – 05. 05. 2018, 1 male, 19. 05. – 01. 06. 2018, 1 male. Frequent, West Palaearctic species. Larva on *Alnus* spp.

Genus *Nematus* Panzer, 1801*

42. *Nematus lucidus* (Panzer, 1801)*

Material examined: Khinotsminda: Cherulisghele River, 01. 06. – 15. 06. 2018, 1 female; Khinotsminda Monastery, 20. 04. – 05. 05. 2018, 1 female. Frequent. Larva on *Crataegus*, *Rosa* spp. and *Prunus spinosa*. Palaearctic.

Genus *Nesoselandria* Rohwer, 1910

43. *Nesoselandria morio* (Fabricius, 1781)

Material examined: Zeraboseli: Kintrishi River, 01. 06. – 15. 06. 2018, 1 female, 29. 06. – 13. 07. 2018, 1 female, 10. 08. – 24. 08. 2018, 2 fenales, 24. 08. – 07. 09. 2018, 4 females, 19. 10. – 03. 11. 2018, 1 female. Frequent. Host plants: *Brachytecium reflexum*, *Ceratodon purpureus*, *Chenopodium album*, *Dicranum scoparium*, *Fragaria vesca*, *Hedwigia ciliata*, *Myosotis arvensis*, *Plagiomnium cuspidatum*, *Plagiothecium denticulatum*, *Polygonum aviculare*, *Polytrichum commune*, *Pseudobryum cinclidiodes*, *Sanionia uncinata*, *Stellaria media*, *Veronica chamaedrys* and *V. officinalis*. Holarctic.

Genus *Pachyprotasis* Hartig, 1837*

44. *Pachyprotasis rapae* (Linné, 1767)*

Material examined: Zeraboseli: Kintrishi River, 23. 04. – 05. 05. 2018, 3 females, 05. 05. – 20. 05. 2018, 1 female, 19. 05. – 01. 06. 2018, 3 males, 01. 06. – 15. 06. 2018, 1 male; Khinotsminda: Cherulisghele River, 20. 04. – 05. 05. 2018, 1 female, 05. 05. – 20. 05. 2018, 1 male. Common Holarctic species. Hostplants: *Solanum tuberosum*, *Pedicularis palustris*, *Angelica sylvestris*, *Veronica beccabunga*, *Betonica officinalis*, *Corylus avellana*, *Salix caprea*, *Fraxinus excelsior*, *Tussilago farfara*, *Symphoricarpos albus*, *Scrophularia*, *Solanum*, *Solidago virgaurea*, *Verbascum*, *Origanum vulgare*, *Atropa belladonna*, *Sarothamnus*, *Senecio*, *Polygonum*, *Lamium*, *Aspidium*, *Epilobium*, *Hypericum*, *Galeopsis*, *Glechoma*, *Mentha*, *Polystichum*, *Plantago*, *Misopates*, *Veronica*, *Quercus* and *Stachys* spp.

Genus *Parna* Benson, 1936*

45. *Parna tenella* (Klug, 1816)*

Material examined: Zeraboseli: Kintrishi River, 23. 04. – 05. 05. 2018, 3 females. Sporadic,West Palaearctic species. Larva inside the leaves of *Tilia* spp.

Genus *Profenusa* MacGillivray, 1914*

46. *Profenusa thomsoni* (Konow, 1886)*

Material examined: Zeraboseli: Kintrishi River, 05. 05. – 20. 05. 2018, 1 female, 10. 08. – 24. 08. 2018, 1 female. Sporadic, Palaearctic species. Host plants: *Betula* spp.

Genus *Priophorus* Dahlbom, 1835*

47. *Priophorus brullei* Dahlbom, 1835*

Material examined: Zeraboseli: Kintrishi River, 05. 05. – 20. 05. 2018, 1 male, 19. 05. – 01. 06. 2018, 4 males, 01. 06. – 15. 06. 2018, 15 males, 2 females, 15. 06. – 29. 06. 2018, 6 males, 29. 06. – 13. 07. 2018, 10 males, 13. 07. – 27. 07. 2018, 51 males, 1 female, 27. 07. – 10. 08. 2018 , 15 males, 1 female,10. 08. – 24. 08. 2018, 8 males, 24. 08. – 07. 09. 2018, 15 males, 2 females, 07. 09. – 21. 09. 2018, 1 male, 1 female, 21. 09. – 05. 10. 2018, 1 female; Khinotsminda Monastery, 20. 04. – 05. 05. 2018, 1 female, 27. 07. – 10. 08. 2018, 1 male, 07. 09. – 21. 09. 2018, 2 females. Common. Larva on *Rubus* spp. like *R. idaeus*, *R. caesius* and *R. saxatilis*. Cosmopolitan.

48. *Priophorus compressicornis* (Fabricius, 1804)*

Material examined: Khinotsminda Monastery, 15. 06. – 29. 06. 2018, 1 female. Frequent pest. Hostplants: *Betula*, *Cotoneaster*, *Prunus*, *Rubus*, *Sorbus*, *Fragaria*, *Crataegus*, *Corylus* and *Rosa* spp. Holarctic.

Genus *Pristiphora* Latreille, 1810

49. *Pristiphora* (Pristiphora) *armata* (Thomson, 1863)*

Material examined: Zeraboseli: Kintrishi River, 23. 04. – 05. 05. 2018, 2 females, 1 male, 05. 05. – 20. 05. 2018, 1 male, 19. 05. – 01. 06. 2018, 3 females, 01. 06. – 15. 06. 2018, 1 female; Khinotsminda Monastery, 20. 04. – 05. 05. 2018, 1 male. Frequent Palaearctic species. Larva on *Crataegus* spp.

50. *Pristiphora* (Lygaeophora) *lanifica* (Zaddach, 1883)*

Material examined: Zeraboseli: Kintrishi River, 13. 07. – 27. 07. 2018, 1 female, Khinotsminda Monastery, 20. 04. – 05. 05. 2018,1 female. Sporadic, West-Palaearctic species. Larva on *Salix* spp.: *S. aurita*, *S. livida* and *S. caprea*.

51. *Pristiphora* (Pristiphora) *leucopus* (Hellén, 1948)*

Material examined: Khinotsminda Monastery, 20. 04. – 05. 05. 2018, 1 female, 1 male, 15. 06. – 29. 06. 2018, 1 female, 24. 08. – 07. 09. 2018, 1 female. Frequent, West-Palaearctic species. Larva on *Tilia* spp.

52. *Pristiphora* (Pristiphora) *pallidiventris* (Fallén, 1808)

Material examined: Zeraboseli: Kintrishi River, 15. 06. – 29. 06. 2018, 1 female, 29. 06. – 13. 07. 2018, 1 female; Khinotsminda Monastery, 20. 04. – 05. 05. 2018, 1 female, 01. 06. – 15. 06. 2018, 1 female. Frequent. Larva on *Geum*, *Potentilla*, *Rubus* and *Filipendula* spp. Holarctic.

Genus *Pteronidea* Rohwer, 1911*

53. *Pteronidea* (Pteronidea) *glutinosae* Cameron, 1882*

Material examined: Zeraboseli: Kintrishi River, 23. 04. – 05. 05. 2018, 5 males, 05. 05. – 20. 05.

2018, 1 female, 19. 05. – 01. 06. 2018, 4 males, 01. 06. – 15. 06. 2018, 4 males, 15. 06. – 29. 06. 2018, 1 male. Sporadic, West Palaearctic species. Hostplant: *Alnus* spp.

54. *Pteronidea* (Pteronidea) *myosotidis* (Fabricius, 1804)*

Material examined: Zeraboseli: Kintrishi River, 23. 04. – 05. 05. 2018, 1 female, 05. 05. – 20. 05. 2018, 1 female, 1 male; Khinotsminda: Cherulisghele River, 05. 05. – 20. 05. 2018, 1 male; Khinotsminda Monastery, 20. 04. – 05. 05. 2018, 1 female, 19. 05. – 01. 06. 2018, 1 female, 27. 07. – 10. 08. 2018, 2 males. Common. Larval hosts: *Onobrychis*, *Vicia, Trifolium* spp. and *Lathyrus pratensis*. Palaearctic.

Genus *Rhogogaster* Konow, 1884

55. *Rhogogaster* (Rhogogaster) *chlorosoma* (Benson, 1943)*

Material examined: Zeraboseli: Kintrishi River, 05. 05. – 20. 05. 2018, 1 female, 19. 05. – 01. 06. 2018, 2 females, 01. 06. – 15. 06. 2018, 1 female, 15. 06. – 29. 06. 2018, 1 female. Frequent. Host plants: *Salix alba*, *S. purpurea*, *Salix* spp.. Palaearctic.

Genus *Sciapteryx* Stephens, 1835

56. *Sciapteryx circassica* Dovnar-Zapolskij, 1930

Material examined: Zeraboseli: Kintrishi River, 23. 04. – 05. 05. 2018, 1 female, 1 male. Sporadic, Ponto-Caspian species. Hostplant unknown.

Genus *Sharliphora* Wong, 1969*

57. *Sharliphora parva* (Hartig, 1837)*

Material examined: Khinotsminda Monastery, 20. 04. – 05. 05. 2018, 1 female. Sporadic, West Palaearctic species. Larva on *Picea* spp.

Genus *Stauronematus* Benson, 1953*

58. *Stauronematus platycerus* (Hartig, 1840)*

Material examined: Zeraboseli: Kintrishi River, 23. 04. – 05. 05. 2018, 1 female. Sporadic, Palaearctic species. Larva on *Populus tremula*, *P.nigra* and *P. balsamifera*.

Genus *Strongylogaster* Dahlbom, 1835

59. *Strongylogaster caucasica* Schaposchnikov, 1885*(Fig.3C)

Material examined: Khinotsminda Monastery, 20. 04. – 05. 05. 2018, 5 females. Sporadic. Hostplants unknown. Ponto-Caspian.

60. *Strongylogaster macula* (Klug, 1817)*

Material examined: Zeraboseli: Kintrishi River, 23. 04. – 05. 05. 2018, 1 female. Sporadic, Holarctic species. Hostplants: *Athyrium filix-femina*, *Dryopteris filix-mas*, *Polystichum aculeatum* and *Pteridium aquilinum*.

61. *Strongylogaster multifasciata* (Geoffroy, 1785)

Material examined: Zeraboseli: Kintrishi River, 23. 04. – 05. 05. 2018, 9 females, 05. 05. – 20. 05. 2018, 1 female, 15. 06. – 29. 06. 2018, 1 female, 27. 07. – 10. 08. 2018, 1 female, 10. 08. – 24. 08. 2018, 1 female; Khinotsminda: Cherulisghele River, 20. 04. – 05. 05. 2018, 2 females, 05. 05. – 20. 05. 2018, 1 female; Khinotsminda Monastery, 27. 07. – 10. 08. 2018, 1 female. Frequent. Hostplants: *Dryopteris* sp., *Matteuccia struthiopteris*, *Aspidium* sp., *Polystichum* sp. and *Pteridium aquilinum*. Palaearctic.

Genus *Tenthredo* Linné, 1758

62. *Tenthredo* (*Tenthredella*) *procera* Klug, 1817*

Material examined: Zeraboseli: Kintrishi River, 05. 05. – 20. 05. 2018, 1 female. West Palaearctic, sporadic species. Hostplants: *Petasites* and *Symphytum* spp.

63. *Tenthredo* (*Tenthredella*) *purpurea* Puls, 1870

Material examined: Zeraboseli: Kintrishi River, 23. 04. – 05. 05. 2018, 1 female. Sporadic, Ponto-Caspian. Hostplant unknown.

Genus *Tenthredopsis* Costa, 1859

64. *Tenthredopsis friesei* (Konow, 1884)*

Material examined: Khinotsminda Monastery, 01. 06. – 15. 06. 2018, 3 females, 15. 06. – 29. 06. 2018, 5 females. Frequent. Host plants: *Holcus mollis* and other Poaceae. Palaearctic.

Family – Xiphydriidae

Genus *Xiphydria* Latreille, 1803

65. *Xiphydria caucasica* Semenov & Gussakovskij, 1935

Material examined: Khinotsminda Monastery, 27. 07. – 10. 08. 2018, 1 female. Sporadic, Ponto-Caspian species. Hostplant unknown.

Species richness

Sixty-five sawfly species were identified from a total of 1,703 specimens collected in Kintrishi National Park at three different altitudes using Malaise traps. Sixteen genera and 42 species were recorded from Georgia (Sakartvelo) for the first time. This brings the number of Sympyta species recorded in Georgia to 147. We believe that this number will at least double in our future studies.

Seasonal dynamics of flight activity of sawflies

Seasonal dynamics in abundance of sawflies in the Alpine biogeographical region to which Kintrishi National Park belongs, were studied using Malaise traps in the Western Carpathians, Central Europe [42]. The patterns of seasonal distribution of sawflies in the Carpathians were very different from those we observed in Georgia. In the submontane zone of the Carpathians, a prominent activity peak in early June is followed by a second summer peak, sometimes absent (Štefanová) and sometimes as prominent as the spring peak (Hriňová). In the Pannonian biogeographical region, according to our experience [43-51], the flight activity curve always follows the pattern shown in Fig.4. The curves were not figured but the already published faunistic data were analysed and will be published separately. In this point, the fligth activity curve of the Ponto-Caspian Alpine region is strickingly different from that of the Central European Alpine region and in interesting way, it perfectly agrees with the flight activity curves in the Pannonian biogeographical region.

Two peaks were observed during the year, which can be modelled by a normal distribution. The first curve is the spring flight season and the second is the summer flight season. These 2 curves are separated by 40 days when the densities of imago populations are lowest (in the Pannonian Zoogeographic region this low intermediate period is close to zero, and in the neighbouring Anatolian zoogeographical region there is no second curve).

The peak of the first curve was 399 specimens collected (between 23. 04. and 05. 05.), while the peak value of the second curve was 180. The approximate ratio is 2:1 (in the Pannonian region this ratio varies strongly between 2:1 and 7:1). The beginning of the first flight period is uncertain and ends in the second decade of August, while the second flight period begins in the second decade of August and ends in the last decade of October.

Seasonal dynamics of species richness

During the first culmination, we caught 60 species, but during the second culmination only 28 species. The first culmination period was between 23. 04. and 05. 05. And the second culmination period was between 27, 07.. and 10. 08 (Fig.5). After the second culmination period, in early autumn, only four to five species occured. The number of species was 2 times higher in the first spring period than in the second summer period. This ratio could behigher for the first period, as the earliest sawfly species were not recorded. In the Pannonian zoogeographical region, this ratio is 1: 12 for the spring period, in the Anatolian zoographical region, there is no second period.

Only representatives of Pamphilidae, Argidae, Cephidae and Tenthredinidae were collected. Species of other Symphyta families are probably not common in Kintrishi National Park or the positions of the Malaise traps did not cover the whole vegetation with special attention to conifers and birches (*Betul*a spp.).

Biodiversity and dominancy indices

The dominant species was *Allantus cinctus* with 490 specimens, ahead of *Birka catellata* with 156 specimens, *Cladius brullei* with 138 specimens, *Metallus pumilus* with 125 specimens, *Macrophya albicincta* with 122 specimens and *Eurhadinoceraea fulviventris* with 106 specimens. These 6 species (over 100 specimens each) account for 66.8% of the total collected material. However, further research is needed to determine which species dominate the sawfly fauna overall and which species only had outbreak in 2018.

Biodiversity and dominance indices (Table 1) are good tools to track spatial and temporal changes in biodiversity and species composition. They are very important to compare different areas and different time periods and to identify trends. They are also useful for conservation and zoogeography. Unfortunately, these indices have not yet been used in Georgian sawfly faunistics .

Table 1. *Biodiversity and dominance indices, Kintrishi National Park, 2018*

Indices	Values	Indices	Values
Simpson Index	0.118768	Buzas and Gibson's Index	0.253076
Dominance Index	0.881232	Equitability Index	0.670835
Reciprocal Simpson Index	8.41977	Margalef Richness Index	8.60402
Shannon Index log2	4.04001	Berger-Parker Dominance Index	0.288235
Shannon Index ln	2.80032	Inverted Berger-Parker Dominance Index	3.46939
Shannon Index log10	-1.21617	Gini Coeffificient	0.783891
Menhinick Index	1.57648		

These indices above (in contrast to the curves of flight activity and biodiversity dynamics) show a close relationship with the Anatolian sawfly fauna [52] (personal communications). No significant differences were found in any of the above parameters compared to the Anatolian zoogeographical region (these values will be published separately). Conversely, there was no overlap with the Pannonian zoogeographic region in any of the above indices, although, the similarity between the 2 regions in species composition is 84% and in addition the curves (discussed previously) strictly follow the available data from the Pannonian region.

Abundance and species richness of sawflies as a function of altitude.

Abundance of sawflies and their species richness were measured at 3 different altitudes, namely 404 metres, 1,020 metres and 1,284 metres. The highest diversity and abundance, 83.1% of sawflies (1,416 specimens), were collected at the altitude of 404 metres (Zeraboseli: Kintrishi River). 172 specimens (10.1%) were collected at 1,020 meters and only 115 specimens (6.8%) in 1,264 metres (Fig.6).

The number of sawfly species was also lowered depending on the altitude. 56 species was cought at 404 metres altitude, 30 at 1,020 metres and 19 at 1,264 metres. *Janus cynosbati* (Linné, 1758), *Xiphydria caucasica* Semenov & Gussakovskij, 1935, *Strongylogaster caucasica* Schaposchnikov, 1885, *Tenthredopsis friesei* (Konow, 1884), *Priophorus compressicornis* (Fabricius, 1804), *Hemichroa australis* (Serville, 1823), *Nematus lucidus* (Panzer, 1801), *Pristiphora leucopus* (Hellén, 1948) and *Pristiphora parva* (Hartig, 1837) were only caught at higher altitudes. This decline in species richness at higher altitudes is probably due to the vegetation zones and climatic conditions at the different altitudes.

Zoogeographical analysis

The proportion of the collected sawfly species with the specific zoogeographical distribution can be found in Table 2.

Table 2. *Zoogeographical composition of sawflies, Kintrishi National Park, 2018.*

Zoogeographical area	Number of species	%
Ponto-Caspian-Persian	2	3.1
Ponto-Caspian	7	10.8
Ponto-Caspian-Turanian	1	1.5
West-Palaearctic	21	32.3

Palaearctic	20	30.8
Southern Palaearctic	1	1.5
Holarctic	12	18.5
Cosmopolitan	1	1.5

Most recorded species have a wide range: Holarctic, Palaearctic, West Palaearctic and Cosmopolitan. Their proportion is 84.6 %. The so-called characteristic components are the species with narrow ranges: Ponto-Caspian, Ponto-Caspian-Turanian and Ponto-Caspian-Persian components. These species are: *Onycholyda trigaria* (Konow, 1897), *Pamphilius pugnax* Konow, 1897, *Xiphydria caucasica* Semenov & Gussakovskij, 1935, *Birka catellata* (Konow, 1900), *Strongylogaster caucasica* Schaposchnikov, 1885, *Metallus beckeri* (Konow, 1904), *Eutomostethus ephippium* ssp. *vopiscus* (Konow, 1899), *Macrophya hamata* ssp. *caucasicola* Muche, 1969, *Sciapteryx circassica* Dovnar-Zapolskij, 1930 and *Tenthredo purpurea* Puls, 1870, accounting for 15.4%. 84% of the recorded species belong to the Pannonian faunal elements, while only 12% belong to the Anatolian faunal elements, although the Anatolian region is less tha 120 km away from the study area.

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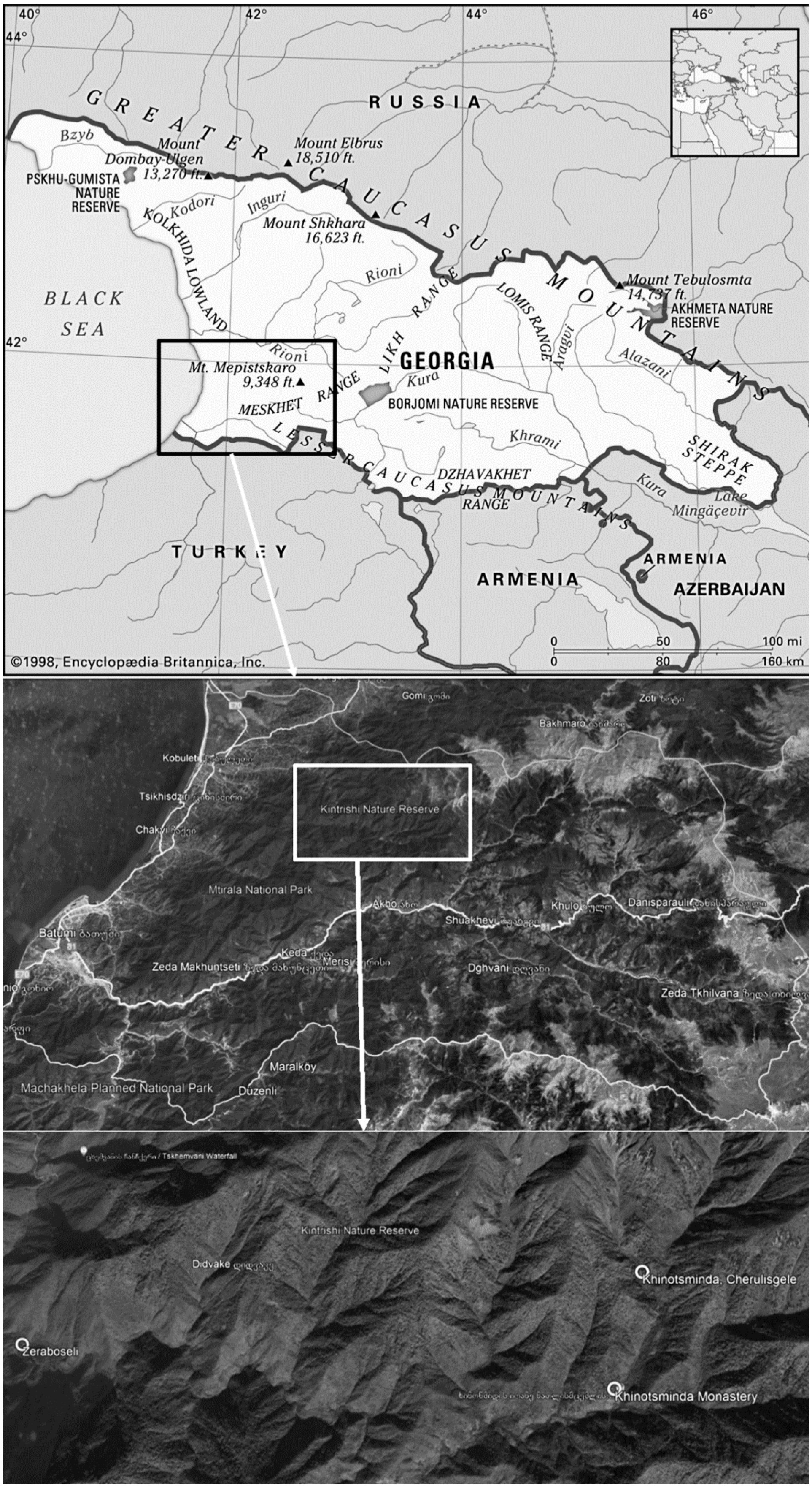

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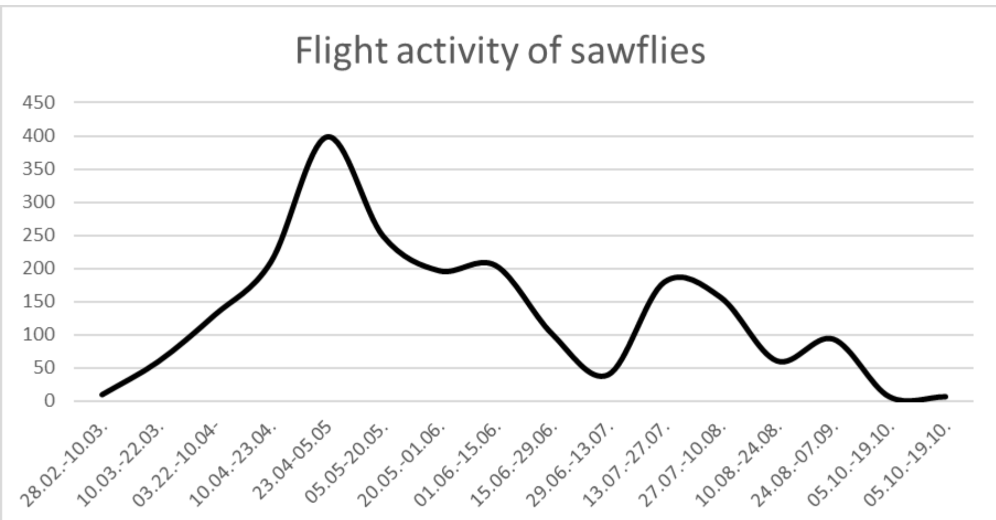

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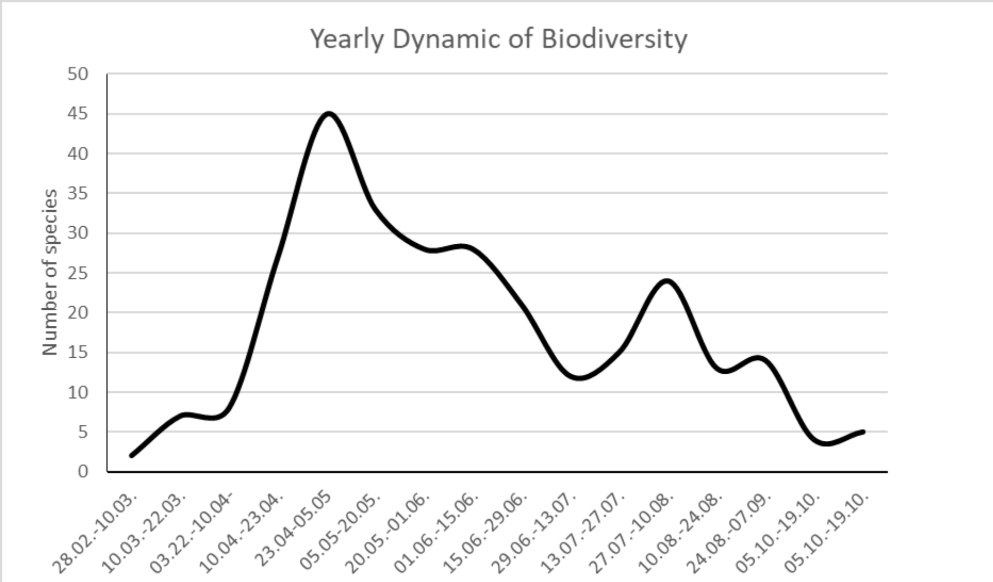

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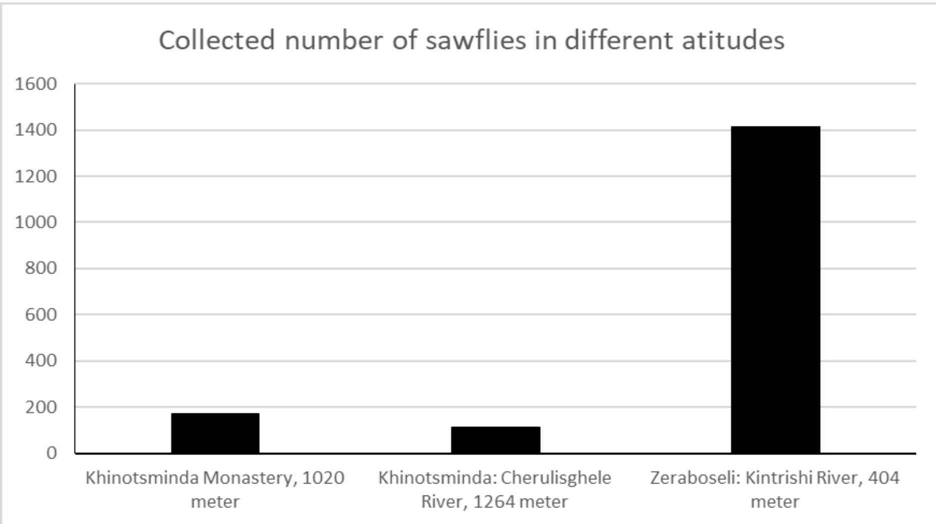

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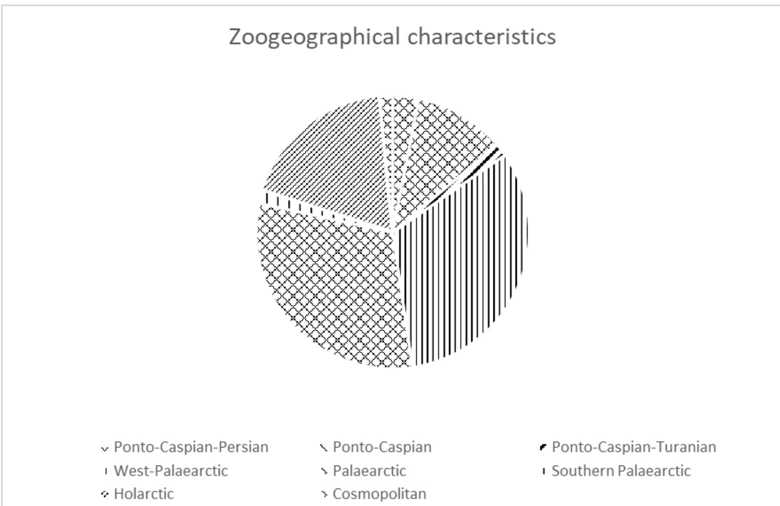

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Climatic risks created by dangerous weather phenomenain Kvemo Kartli

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A B S T R A C T

Kvemo Kartli is directly adjacent to the capital of Georgia and supplies it with essential agricultural products. Hazardous weather conditions typical for the region negatively affect all sectors of the region's economy and the country as a whole. Therefore, to mitigate the expected negative consequences in the region, based on the observations of 8 meteorological stations, the probabilities of typical hazardous weather phenomena and the possible social and economic risks associated with these phenomena were studied with unfavorable weather conditions. It was found that for the region as a whole, the most significant social and economic risks are represented by fog and strong wind.

Key words: dangerous phenomenon, probability, vulnerability, social and economic risk.

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Introduction

Today's global warming is accompanied by growing damage worldwide from hazardous weather and climate events. About 90% of the most severe economic losses are caused not by such natural phenomena as volcanic eruptions, tsunamis, and earthquakes but by hydrometeorological phenomena: floods, strong winds, torrential rains, hail, droughts [1,2]. Thus, we can talk about climatic risk if dangerous or unfavorable meteorological phenomena are observed in a given area and a particular object (risk recipient) is under their probable influence.

Hazardous phenomena are the leading cause of accidents and disasters associated with meteorological factors. In order to develop measures to neutralize and mitigate the action of hazardous phenomena, it is necessary to quantify the possibility of their occurrence in different geographic conditions and the associated losses. That will make it possible to determine the risk, which quantitatively expresses the effect of a hazardous phenomenon in a probabilistic form [3].

This article presents the results of a study of some dangerous weather phenomena and assesses the climatic risks they create in the Kvemo Kartli region (Georgia). The study region was not chosen by chance; the capital of Georgia is directly adjacent to it from the north, which the region supplies with agricultural products. The administrative region includes 1 city of regional subordination and 6 municipalities. The region's population is multinational and amounts to 432,300 people, and its area is 6,528 sq. Km (Table 1).

Table 1. *Area and population of municipalities*

Municipality	square, km²	population grade 2018 people	Centre
Tsalka municipality	1051	19 302	Tsalka
Tetritskaro municipality	1174	21 889	Tetri-Tskaro
Rustavi city	60	127 839	-
Marneuli municipality	935	106 454	Marneuli
Dmanisi municipality	1199	20 216	Dmanisi
Gardabani municipality	1304	81 280	Gardabani
Bolnisi municipality	804	55 284	Bolnisi
Total	6528	432 264	Rustavi

Typical for the region, such dangerous weather conditions as fog, strong wind, hail, heavy rainfall, and snowstorms negatively affect all sectors of the region's economy, causing significant material damage and even human casualties. For example, according to official data, material damage from a strong wind observed on March 4, 1973 in the Tbilisi-Bolnisi region amounted to 5 million US dollars. A strong wind on October 26, 1962 caused damage to the Tetri-Tskaro district of $ 400,000, and on January 24, 1963, Dmanisi district caused damage to $ 200,000. On March 5, 1966, heavy fog caused US $ 10,000 in damage to the region.

In order to mitigate the expected negative consequences of hazardous phenomena and unfavorable weather conditions, it is necessary to assess the associated potential risks, compare them with the value of the acceptable risk and then make decisions on adaptation [4].

Materials and methods

Climate risk is a combination of the likelihood and consequences of a hazardous or adverse event occurring. Risk is defined as the product of the probability of a specific meteorological hazard by the conditional probability of the vulnerability of the recipient who may be exposed to this hazard [4]:

$$R=pU \quad (1)$$

where: **p**- is the probability of an event; U- is the consequences of an event or the vulnerability of an object exposed to a hazardous phenomenon, which is determined by the formula:

$$U=(s/S)\cdot m\cdot t\cdot K \quad (2)$$

s — average impact area of this phenomenon (sq. km),

S — administrative area (sq. km),

m — population of the administrative region (people),

t — time of action of a dangerous meteorological phenomenon or unfavorable weather conditions (day);

K — coefficient of aggressiveness of the phenomenon.

Vulnerability depends on the geography and the degree of development of the affected area. The more developed the economy, the more damage occurs when dangerous phenomena pass through it.

It is customary to call climatic risk social, i.e., the risk of social damage to the territory, under consideration since it determines the size of the population affected by this phenomenon. The general formula for social risk or the likelihood of injury for a particular recipient is as follows [4,5]:

$$Rc=p(s/S)(si/S)\cdot m\cdot t\cdot K \quad (3)$$

where **si** - recipient area, sq. km.

The basis of the economic risk management mechanism is determining the economic damage caused by a hazardous event. The cumulative damage in a given area is called economic risk. Economic risk is the product of the probability of a meteorological hazard by the amount of damage; expressed in monetary units [4,5]:

$$Re=ARc=p(s/S)(si/S)\cdot m\cdot t\cdot K\cdot A \quad (4)$$

where **A** -is the share of gross domestic product per day per inhabitant of a given administrative region.

The article discusses the weather phenomena that create emergencies in the region:

- Abundant precipitation (**R30**, when the daily precipitation is at least 30 mm).
- Hail (**Ha**).
- Fog (**F**).
- Strong wind (**W**, when the wind speed is not less than 15m / s).

• Blizzard (**B**).

The materials of observations of 8 meteorological stations in the region were used (Table 2).

Table 2. *Used material*

Station	Height above sea level m	Used material, yy
Tsalka	1457	**1961-2019**
Tetri-Tskaro	1140	**1961-2006**
Bolnisi	534	**1961-2019**
Gardabani	300	**1961-2006**
Dmanisi	1256	**1961-2006**
Marneuli	432	**1961-2019**
Manglisi (Tetritskaro municipality)	1191	**1961-2006**
Rustavi	374	**1961-2015**

To restore the available individual missing data in the observation series, we used the approach we repeatedly tested [6]: correlation matrices were compiled for all stations and, based on their statistical analysis, and taking into account the physical and geographical conditions of the station location, groups of highly correlated stations were identified, which for the studied phenomenon were significant at the level of 95% or more. Further, the missing data was determined by applying the method of corresponding relations.

All calculations were performed following the methods developed under the guidance of NV Kobysheva [4,5]. The aggressiveness coefficients of the phenomena are taken in accordance with [4], and the areas of influence of this phenomenon are taken from our previous studies [7-12] (table 3). Since meteorological phenomena are seasonal, the calculations were performed separately for each season.

Table 3. *The coefficient of aggressiveness (K) and the average area of influence (s) of the phenomenon*

Characteristic	Meteorological phenomenon				
	R30	**Ha**	**F**	**W**	**B**
K	0.03	3	0.5	1.0	0.8
s sq. km	3000	7	6000	4000	5

The discussion of the results

Figure 1 shows the daily probabilities of some dangerous meteorological phenomena in individual municipalities of the region by seasons.

It follows from Fig. 1 that fog is the most frequent of the considered phenomena in the region. It is observed in all areas in all seasons, relatively rare in summer. The probability of fog in Tetri Tskaro is about 0.3; in Dmanisi, it exceeds 0.2, and in the rest of the region, it exceeds 0.1. Strong winds are also often noted, especially in Gardabani and Dmanisi, and hail is most dangerous in Bolnisi, where its probability in spring exceeds 0.1, i.e., drops out every 10 days. Blizzards are observed in Dmanisi in almost all seasons. Heavy rainfall is rare.

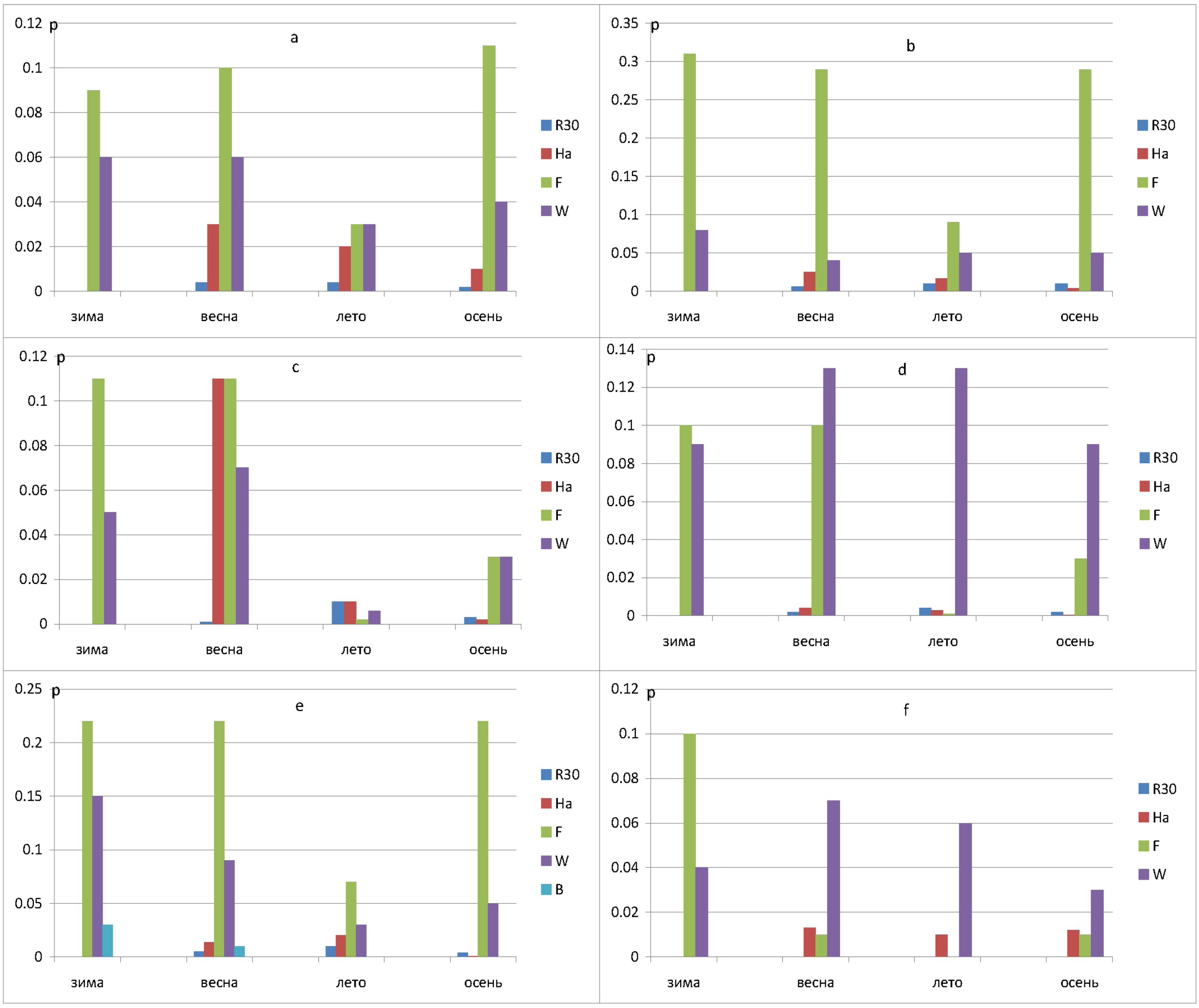

Fig. 1 *Probability of some dangerous meteorological phenomena by municipalities: a-Tsalka, b-Tetri-Tskaroi, c-Bolnisi, d-Gardaban, e-Dmanisi, f-Marneuli*

Table 4 presents data on social and economic risks from hazardous weather phenomena, calculated according to formulas (3) and (4). When calculating the economic risk, the gross domestic product (GDP) was assumed to be $ 26 (in 2015 prices).

Table 4. *Social (Rs people) and economic (Re US dollars in 2015 prices) risks from one phenomenon by municipalities of the region*

Administrative region	Pheno-menon	Season							
		Winter		spring		Summer		Autumn	
		Rc	**Re**	**Rc**	**Re**	**Rc**	**Re**	**Rc**	**Re**
Tsalka	**R30**	0	0	4	104	4	104	2	52
	Ha	0	0	6	156	4	104	2	52
	F	2881	74906	3201	83226	960	24960	3521	91546
	W	2547	66222	2547	66222	1273	33098	1998	51948

Tetri-Tskaroiskiy	**R30**	1	26	6	156	11	286	11	286
	Ha	0	0	6	156	4	104	1	26
	F	11086	288236	10371	269646	3218	83668	10371	269646
	W	3794	98644	1897	49322	2371	61646	2371	61646
Bolnisi	**R30**	0	0	1	26	7	182	2	52
	Ha	0	0	2	52	2	52	1	26
	F	2693	70018	2693	70018	49	1274	735	19110
	W	1623	42198	2272	59072	194	5044	974	25324
Gardabani (including the city of Rustavi)	**R30**	0	0	2	52	5	130	2	52
	Ha	0	0	1	26	1	26	1	26
	F	3972	103272	3972	103272	40	1040	1191	30966
	W	4740	123240	6847	178022	6847	178022	4740	123240
Dmanissky	**R30**	0	0	6	156	12	312	5	130
	Ha	0	0	4	104	5	130	1	26
	F	8035	208910	8035	208910	2556	66456	8035	208910
	W	725	18850	4359	113334	1453	37778	2421	62946
	B	2	52	1	26	0	0	0	0
Marneulsky	**R30**	0	0	2	52	6	130	2	52
	Ha	0	0	2	52	2	52	2	52
	F	2848	74048	285	7410	0	0	285	7410
	W	1510	39260	2644	68744	2266	58916	1133	29458

Social risk indicates the number of people affected at a certain level, and it characterizes the severity of the consequences (catastrophic) of the implementation of hazards.

It follows from Table 4 that fog and strong winds pose the most significant risk for the region as a whole. In terms of the impact of these phenomena, the Tetri-Tskaro and Dmanisi districts are the most sensitive. In the latter area, a blizzard also poses a risk. In addition, it follows from Table 4 that the distribution of social risks is seasonal. In particular, the greatest risk from fog is expected mainly in the autumn-winter or spring period; in summer, it decreases slightly or is absent altogether. Depending on the physical and geographical conditions, the social risk from strong wind is most remarkable in winter or spring.

The economic risk is also most significant from fog and strong winds. For example, in the Tetri-Tskaroi region in winter, the economic risk from the fog in one case may amount to more than 288 thousand US dollars. The economic risk from strong winds in the Dmanisi region exceeds USD 208 thousand, and in the Gardabani region, it exceeds USD 178 thousand. These phenomena are observed in the region several times during the year, so the economic risk can range from several to tens of millions of US dollars per year.

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Influence of stress metabolite stilbenoids of Shavkapito vine trunk (*Vitis vinifera* L.) on the activity of Crown gall agent Agrobacterium *tumefaciens in vitro condition*

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A B S T R A C T

It was investigated the impact of stress metabolite stilbenoids of Shavkapito vine trunk (*Vitis vinifera* L.) on the activity of crown gall agent *Agrobacterium tumefaciens "in vitro"* condition. Health and infected vine trunks were brought from the east part of Georgia (village Mukhrani) on the Eutric cambisols soil of 15 years old vineyard. It was isolated strong, medium and weak bacterial strains from the naturally diseased with Agrobacterium tumefaciens Shavkapito trunk. It was established stress-metabolite stilbenoids from the healthy and infected trunks by HPLC analyze. Main stilbenoids turned out trans-resveratrol and trans-ε-viniferin. It was investigated inhibitory impact of trans-resveratrol, trans-e-viniferin and stilbenoids total preparation on strong, medium and weak bacterial strains. It occurred that stilbenoids inhibitory impact depends on concentration and detect differently according to the strains strength.

Key words: vine, stilbenoids, Shavkapito, crown gall

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Introduction

The most important physiological role of vine stilbenoids are phytoalexin treatment. According to previous studies developed by the Institute of Viticulture and Enology of the Agricultural University of Georgia, the vine stilbenoids are involved for responses toward bacterial (*Agrobacterium tumefaciens*) and fungal diseases in grape varieties. Crown gall infected vines of the grape varieties – Rkatsiteli, Saperavi, Cabernet Sauvignon, Tsitska and Tsolikouri were identified in East and West regions of Georgia; healthy vines were considered, as well. Stilbenoid- containing fractions were isolated from the trunk of the infected and healthy vines and the single compounds were identified (trans-resveratrol and trans -ε- viniferin). The grape variety had a crucial role in the amount of detected stilbenoids. The obtained results were important for identifying the correlation of the immunity of the grape varieties with the phytoalexin stilbenoids [1]. Healthy and crown gall infected vines of *V. vinifera* L, cvs. Saperavi and Rkatsiteli were selected from vineyards in East region of Georgia, in 2018 and 2019. Samples of infected and healthy vines were taken in February – March 2018 in a 16-year-old vineyard and in January 2019 in a 24-year-old vineyard, both located on an alluvial soil. Stilbenoids (trans-resveratrol and trans-ε-viniferin) were isolated from the infected and healthy vine trunks and analyzed by HPLC/MS, with three replicates. The concentrations of *trans*-ε-viniferin in healthy trunks of the 24- year-old Saperavi and Rkatsiteli, were higher than the concentration of *trans*-resveratrol. On the other hand, in the healthy trunks of 16-year-old vines, the concentration of *trans*-resveratrol exceeded the concentration of trans- ε- viniferin. In the crown gall infected 24-year-old vines, the concentration of trans-resveratrol increased while the concentration of trans- ε- viniferin decreased [2].

The trunk stilbenoids of healthy and crown gall infected vines of Georgian red vine variety - Ojaleshi was studied and identified as stress-metabolite compounds: cis-piceid, trans-resveratrol, trans-ε-viniferin, cis-miyabenol C, cis-miyabenol. The concentrations were higher in infected vines compared to the healthy ones. Among the stress-metabolite stilbenoids were dominating trans-resveratrol and trans-e-viniferin, which concentrations increase under bacterial cancer disease condition. In concrete: trans-resveratrol-2,45g/kg - 3,28g/kg; for trans-ε-viniferin 7,18g/kg - 8,35g/kg [3].

It was established stress-metabolite stilbenoids from Tavkveri grape vine variety trunk in condition bacterial cancer disease. Received results are following: trans-resveratrol increases from 1.65 g/kg to 4.54 g/kg and cis—δ- viniferin, which decreases from 4.27 to 2.47 g/kg [4].

A strain of *Agrobacterium tumefaciens*, isolated from the trunk of infected *V. vinifera* L. cv. Rkatsiteli was studied microscopically and its pathogenesis was established. The goal of the research was to study the role of stilbenoids on the bacterial growth. The bacterium strain was inoculated in two ways: a) the surface of the growth was covered by a watery suspension of stilbenoids; b) stilbenoids were added to the growth medium before sterilization. In both experimental protocols the concentrations of the stilbenoids were: 1 mg/100 ml, 2 mg/100 ml, 3 mg/100 ml, 4 mg/100 ml, 5mg/100ml, 10 mg /100 ml, 15mg/100ml, 20 mg /100 ml and 30 mg /100 ml. The control version was the same medium without stilbenoids. The incubation period was 14-15 days at 27 °C and all the treatments completely (100%) inhibited *Agrobacterium tumefaciens* growth over the control. A second experiment was set up in order to study the bacterial growth inhibition under stilbenoid concentrations lower than 1 mg/100 ml (ranging from 0.1 mg/100 ml to 0.9 mg/100 ml): the bacterial growth inhibition increased from 0.0 % to 88.0% by increasing the stilbenoid concentrations [5.].

Also, it was studied the concentrations (in the berry skin) of stilbenoids of white wine variety Rkatsiteli under grey mould (*Botrytis cinerea*) attack. Samples of healthy and infected grapes – with 60% gray mould, were taken in 2018 during the technological maturity, from the same vineyard (16-year-old) planted in eastern Georgia. The vineyard soil belongs to meadow cinnamonic – Calcariccambisols and calcic kastanozems type. The stilbenoids profiles of healthly and infected skins were detected by HPLC/MS analysis. The dominant stress-metabolites were trans-resveratrol and its derivatives: trans-piceid, cis-piceid, trans-piceatannol, trans-ε-viniferin. The concentration variability of these stilbenoids under gray mould infection was different, as follows (healthy vs. infected): trans-resveratrol 39.27mg kg^{-1}→57.33mg kg^{-1}; trans-piceid 13.72mgkg^{-1}→29.43mgkg^{-1}; trans-piceatannol 5.37mg kg^{-1}→19.45mg kg^{-1}; trans-ε-viniferin 7.22 mg kg^{-1}→5.13mg kg^{-1}. These are the first evidences of the link stilbenoids –gray mould in the Rkatsiteli variety [6.].

Another trial on the interaction between grey mould infection and stilbene production of the white cv. Tsolikouri was carried out; the vineyard (30-year-old) was cultivated in the west part of Georgia (Zestafoni region) on raw humus calcareous-rendzic-leptosols soil. The production of trans-resveratrol, ε-viniferin, trans-piceid, cis-piceid, trans-piceatannol was elicited by grey mould. These are the first evidences of the link stilbenoids –grey mould in the Tsolikouri variety [7.].

Moreover, a study on the effect of powdery mildew (*Uncinula necator*) infection in the synthesis of stibenoids in the grape white variety Rkatsiteli was developed. Samples of healthy and infected grapes (50% of powdery mildew attack) were taken at the beginning of September 2018 (technological maturity), from the same vineyard (32-year-old) planted in eastern part of Georgia; the vineyard soil belongs to meadow cinnamonic –Calcaric cambisols and calcic kastanozems type. The concentration of stilbenoids increased during the disease and the dominant stress-metabolites were trans- resveratrol and trans-ε-viniferin, while the minor compounds were trans-piceid, cis-piceid, trans-piceatannol and oligomeric stilbenoids. The concentrations of these stilbenoids changed from healthy to infected grapes, as follows: trans-resveratrol 27.7mg/ kg→58.92 mg/ kg(53,0%); trans ε-viniferin 11.22 mg /kg→32.55mg /kg(65,5%); trans-piceid 5.36 mg/ kg→7.27mg /kg(26,3%) ; trans-piceatannol 1.45mg/ kg→2.04 mg/kg(28,9%); cis-piceid 17.75 mg/kg→17.79 mg/kg(0,2%); trans-astringin 14.45mg/kg →16.93mg/kg(12,9%); cis-astringin 15.02 mg/kg→16.78 mg/kg(10,5%). These are the first evidences of the link stilbenoids –powdery mildew in Rkatsiteli grape variety [8].

Another trial included the relationship between leaf stilbenoids of the white grape variety Tsitska, grown in the west part of Georgia and downy mildew infection. The stilbenoids trans-resveratrol and ε- viniferin were higher in the infected vines leaves than in the healthy ones. This is the first study done on Tsitska grape variety concerning this subject [9].

Stilbenoids act against different vine diseases caused by bio factors. The following stilbenoids were identified in the extract of vine (*Vitis vinifera*) trunks, roots and annual shoots: Ampelopsin A, (E)-piceatannol, Pallidol, E-resveratrol, hopeaphenol, isohopeaphenol, (E)-ε-viniferin, (E)-miyabenol C, (E) –w-viniferin, r- and r2-viniferin. It was established that the extract inhibits the growth of sporulation of fungus *Plasmopara viticola* by 50%, while the most active inhibitor of it turned out to be r2-viniferin [10]. Under the influence of *Botrytis cinerea* on the mixture of pterostilbene and resveratrol 7 new stilbens were formed, while 5 new stilbenes were formed from pterostilbene under the same terms. The anti-fungal effect of these stilbenoids was fixed against *Plasmopara viticola* [11]. At three stages of the grape (*Vitis vinifera*) berry development, the berries were infected with *Botritis cinerea* spores „in vitro". In the infected berries, pterostilbene, (E)-ε-viniferin and trans-resveratrol were detected, being (E)-ε-viniferin the most produced [12].

Berries of *Vitis vinifera* L. cv. Barbera in the ripening period were infected with conidial suspension of *Aspergillus japonicus*, *A. ochraceus*, *A. fumigatus* and *A. carbonarius*. The process of formation of ochratoxin A and stilbenoids was assessed. It was found out that all fungi except for *A. fumigatus* significantly increased the concentration of trans-resveratrol and at the same time, trans-piceid stays unchanged. In the berries damaged by *A. ochraceus*, the concentration of piceatannol increased significantly. A large amount of ochatoxin A was synthesized in the berries infected by *A. carbonarius* isolate and the anti-fungal activity of stilbenoids was tested under the following concentrations: 300 mg/g resveratrol and 20 mg/g piceatannol, which were effective for an inhibition of the fungal (*A. carbonarius*) growth [13].

Objects and Methods

The objects of research were: a). healthy and naturally diseased by crown gall (*Agrobacterium tumefaciens*) vine trunks 15-year-old shavkapito (red grape wine variety, *Vitis vinifera* L.) cultivated in Eastern Georgia (village of Mukhrani) on Eutric cambisols type soil; b). Pathogenic bacterial strains of *Agrobacterium tumefaciens* isolated from naturaly diseased by crown gall vine trunk of Shavkapito vine variety. From stilbenoids we used water suspensions of the total preparation, trans-resveratrol and trans-e-viniferine released from the vine at the concentrations indicated in the table.

Isolation bacterial strains and establishing their pathogenesis. We took infected Shavkapito trunk cut peace by bacterial cancer. We crushed it in Rodin, added sterile water and made a bacterial suspension. Prepared in petri dishes (8 cm in diameter) sowed the bacterial suspension to the food area and put it in a thermostat at a temperature of 25-27^{0}C. After 12 hours of incubation, the bacterial colonies developed in the food area. We carefully removed and transplanted it to the same food area in the tubes. Closed tubes were placed in a thermostat at a temperature of 25-27^{0}C. To determine the pathogenesis bacterial colonies developed after 24 hours of incubation were removed and transplanted to sliced healthy carrot rings and were placed in a desiccator. Bacterial growth was observed in the laboratory at a temperature of 22-23^{0}C. According to the intensity of development, we identified strong, medium-strength and weak bacterial strains. We transplanted them into food area prepared in tubes and stored them in appropriate conditions for subsequent studies [14].

Isolation of stilbenoids from healthy and infected with bacterial cancer trunks was made according to the scheme (Fig.1).

The effect of stilbenoids on the activity of bacterial strains was determined by the degree of inhibition of their growth and development "***in vitro***." Prepared in advance food areas in petri dishes were treated with water suspensions of stilbenoids and then transplanted with strong, medium-strength and weak strains of *Agrobacterium tumefaciens*.

As a control variant we used bacterial strains sown in the same food area treated with sterile water. Their growth and development took place under the conditions described above.

Stress-metabolite stilbenoids were analyzed by HPLC method. For this purpose, we used the Varian chromatograph, SupelcosilPM LC18 Column, 250x4,6mm, eluents: A. 0,025% trifluoroacetic acid, B.Acetonitrile:A 80/20. Gradient mode: 0-35 min, 20-50% B, 48-53min, 200% B. Flow rate of the eluent- 1 ml/min; wavelength-306 and 285nm. Isolated stilbenoid-containing fractions were filtered using a membrane filter (0,45µ) before the chromatographic procedure [15].

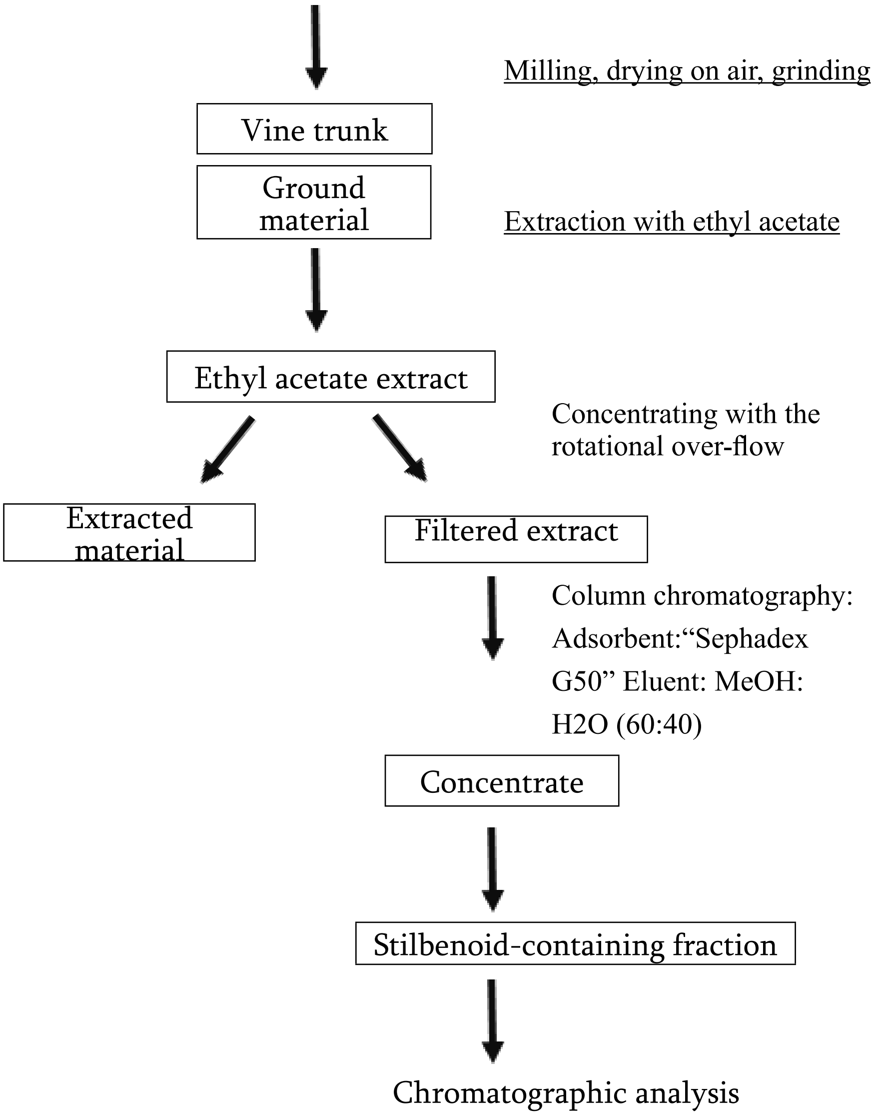

Fig. 1. *Chart of isolating a stilbenoid-containing fraction from vine trunk*

Aim of the research: Aim of the research was Georgian endemic red vine variety Shavkapito trunk health and infected by crown gall (*Agrobacterium tumefaciens*). Determination of phytoalexin stress metabolite stilbenoids. Identification there pathogen strains and study impact of stilbenoids on it activity -inhibition it development.

Results and Discussion.

The difference in the content of stylbenoids of healthy and diseased by bacterial cancer vine trunks of Shavkapito was determined by HPLC analysis. Based on this, the stress metabolite phytoalexin stylbenoids were identified. Main stress metabolite stilbenoids turned out trans-resveratrol and trans-ε-viniferin. In the experiments, we used isolated by us individual trans-resveratrol, trans- ε-viniferine and a total preparation of stilbenoids from the vine.

It was isolated strong, medium and weak bacterial strains from the naturally diseased with Agrobacterium tumefaciens Shavkapito trunk. In the control variants - on food areas not treated with stilbenoids, pathogenic strains of *Agrobacterium tumefaciens* were development as follows: strong -100%, medium- 55%, weak -30%. The development of pathogenic strains on food areas treated with stilbenoids is given in Tables -1,2.

As table 1 shows, stilbenoids inhibitor behavior on the different strength of the bacterial cancer strain is different. In concret, analyzed stilbenoids same concentations in different strength pathogenic strains characterized by different inhibition quality: for totally inhibation strong strain stilbenoids concentration decreises . The concentration of stilbenoid for total inhibition of the strong strain decreases for the pathogenic strain of medium and weak strength.

Above mentioned full dynamic results is given in table 2. In concret, to inhibit totally strong bacterial cancer strain is needed trans-resveratrol concentration 2.8mg/100ml, for medium strength pathogenic strain- 2.6 mg/100ml, weak pathogenic strain-1.6 mg/100ml. Trans-ε-viniferin 2.4 mg/100 ml is enough to inhibit totally strong pathogen strain. For medium strength-2.2 mg/100ml, for weak – 1.4 mg/100ml. Total stilbenoids preparate concentration dynamic is following: for strong pathogenic strain-2.2 mg/100ml, for medium-1.6 mg/100ml, for weak pathogen strain -1.2 mg/100ml.

Conclusion

Theafore, during the carried out research were identified pathogenic strains: strong, medium, weak – from infected by Agrobacterium tumefaciens trunk, of the Georgian red vine grape variety Shavkapito. It was established inhibitor impact of the phytoalexin stilbenoids: trans-resveratrol, trans-ε-viniferin and total stilbenoids preparate on the pathogen strains. Above mentioned stilbenoids, regarding to there inhibition quality are positioned for the following way: stilbenoids complex preparate > trans-ε-viniferin>trans-resveratrol. Research results are important for determine the immunity correlation of Shavkapito vine variety to the phytoalexin stilbenoids.

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Table 1. *Impact of Phytoalexin stilbenoids inhibitor behavior on the pathogen strains development*

N	Stilbenoids	Concentration, mg/100 ml	Bacterial growth Inhibition, %
	Strong Pathogen strain		
1.	Trans-resveratrol	1.0	87.0
		2.0	95.0
		3.0	100.0
		4.0	100.0
		5.0	100.0
2.	Trans-ε-viniferin	1.0	89.0
		2.0	97.0
		3.0	100.0
		4.0	100.0
		5.0	100.0
3.	Total preparat	0.5	82.0
		1.0	90.0
		2.0	99.0
		3.0	100.0
		4.0	100.0
		5.0	100.0
	Medium Pathogen strain		
1.	Trans-resveratrol	1.0	91.0
		2.0	98.0
		3.0	100.0
2.	Trans-ε-viniferin	1.0	93.0
		2.0	99.0
		3.0	100.0
3.	Total preparate	1.0	96.0
		2.0	100.0
	Weak Pathogen strain		
1.	Trans-resveratrol	1.0	95.0
		2.0	100.0
2.	Trans-ε-viniferin	1.0	97.0
		2.0	100.0
3.	Total preparate	1.0	99.0
		2.0	100.0

Table 2. *Dependence of inhibition of bacterial strains development on stylbenoid concentrations*

Stilbenoids concentration, mg/100ml	Inhibition of development,%	Inhibition of development,%	Inhibition of development,%
	for trans-resveratrol	for trans-ε-viniferin	for total preparate
Strong pathogen strain			
1.2	88.5	89.9	91.5
1.4	90.0	91.5	93.0
1.6	91.0	94.0	95.5
1.8	93.0	96.0	97.5
2.0	95.0	98.0	99.0
2.2	96.0	99.0	100.0
2.4	97.5	100.0	100.0
2.6	99.0	100.0	100.0
2.8	100.0	100.0	100.0
3.0	100.0	100.0	100.0
Medium pathogen strain			
1.2	92.0	93.5	97.0
1.4	93.5	94.5	99.0
1.6	95.0	96.0	100.0
1.8	96.5	97.5	100.0
2.0	98.0	99.0	100.0
2.2	98.5	100.0	"—"
2.4	99.5	"—"	"—"
2.6	100.0	"—"	"—"
2.8	100.0	"—"	"—"
3.0	100.0	"—"	"—"
Weak pathogen strain			
1.2	95.0	98.0	100.0
1.4	98.0	100.0	100.0
1.6	100.0	100.0	100.0
1.8	100.0	100.0	100.0
2.0	100.0	100.0	100.0

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Synthesis of biodegradable polymers based on carbamide and formaldehyde

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A B S T R A C T

Biodegradation of polymers of spatial structure is complicated at the impact of soil destructive microorganisms and biodegradation requires long time. We have implemented target-oriented synthesis of a polymer to receive linear structure polymers where labile peptide bonds are preserved.

To realize target-oriented synthesis of polymers and to determine reaction mechanism and optimal conditions of synthesis we studied the process kinetics and reaction regularities -
reaction temperature, pH of reaction medium, duration, components ratio, concentration, reaction speed constant and activation energy,. The Arrhenius factor and succession of introduction of initial components to the reaction medium were computed, catalyst nature and other properties were determined.

High effect of prolongation was achieved, when carbamide and formaldehyde molar ratio was 1:1. In this case linear structure polymer is formed where peptide bonds – CO – NH –) are preserved.

The simplified structure of linear polymer is expressed as followed:

$– HNCONHCH_2 – [NHCONHCH_2]_n – HNCONHCH_2 –$

Key words: Spatial structure, Linear structure, Peptide bond, Microorganisms, Biodegradable, Prolonged action, Synthesis, Temperature, Duration, Catalyst.

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Introduction

Intense growth of the population requires increase of agricultural products, especially of cereal crops but agricultural designation lands suffer constant decrease thanks to the increased urbanization and intensification of industry. The only way to provide the population with farm products is application of nitrogen-containing chemical fertilizers in increased doses (mainly of ammonium nitrate and carbamide). But due to good water solubility of nitrogenous fertilizers their significant part is lost as a result of evaporation and wash-off. Alongside with tremendous economic loss it results in global environment contamination and creates heavy ecological conditions for normal existence of population and fauna.

Regular application of such fertilizers makes unfavorable impact on soil and environment [1-3]. It can condition misbalance of nutrients used by plants, while accumulation of nitrates in great quantity negatively affects human and animal health [4-5].

Efficient way to resolve these problems was creation of absolutely new type fertilizers, the so-called “exchange fertilizers”, which were developed in USA, by the Geological Service [6].

Principle of the application of exchange fertilizer differs cardinally from that of commonly used fertilizers, which are well soluble in ground waters and are easily washed off. Exchange fertilizers consist of hardly soluble ingredients which are released as plant nutrient components and are consumed by plants according to need, due to buffer effect of chemical reactions going on in soil.

The system offered by us is based on the principle that natural ion-exchangers, e.g. zeolites are able to add calcium ion released from Apatite, which is goes on till complete dissolution of Apatite [8-9]. The simplified scheme for this system is as follows:

P-Apatite + (NH_4, K)-zeolite → Ca-zeolite + (NH_4^+ K^+) + $H_2PO_4^-$

Exchange fertilizers are highly efficient for assimilation of nutrients by plants, thus helping plants to assimilate nutrients more efficiently and to decrease washing-off the nutrients and environment pollution.

At the application of exchange fertilizers productivity is increased compared to that when common soluble fertilizers are used. Thus, for example Barbarick and his collaborators [7] proved that productivity of sorgurum-sudangrass in some systems was increased by 4 factors. One of the modifications of this fertilizer was commercialized by Zeoponic Inc (see www.zeoponic.com) and was spread worldwide.

Statement of the problem

Irrespective of these positive results the exchange fertilizers are not perfect for wide application in agriculture. The main problem is that it doesn’t contain much nitrogen (it contains approximately 2.5 mass %) in the form of ammonium ion in zeolite acting in exchange process (NH_4- form of zeolite).

Development of ecologically safe fertilizers is attributed vital significance for our survival.

The submitted project enables us to develop such fertilizers.

Results

Among the nitrogenous fertilizers mainly ammonium nitrate (NH_4NO_3) and carbamide (H_2N-CO-NH_2) are used in agriculture. Carbamide contains up to 46% nitrogen, while nitrate – 35%. But both of them are rather well soluble in water. While introducing into soil their significant part is easily and swiftly washed off at the impact of ground and rain waters, which results in tremendous economic loss, contamination of environment (water reservoirs, lakes, seas, ponds, wells and heavy diseases in the population and animals. At the same time, as a result of evaporation, while reaching the high strata of atmosphere it results in destruction of ozone layer that protects the globe.

According to our opinion one of the efficient ways to overcome these problems is application of polymer fertilizers which are hardly soluble in water. When introduced into soil, at the impact of destructive microorganisms the fertilizer suffers conversion and passes into the form easily assimilated by plants. This process proceeds slowly and a plant manages its assimilation. At the same time, in the vegetation period a plant is provided with dosed and (in case of capsulation) autonomous feeding and it is developed normally, which is a prerequisite of obtaining ecologically pure product and increase of productivity.

Biodegradation of spatial polymer at the impact of destructive microorganisms of soil is complicated and requires a long time. We have implemented a target-oriented synthesis of polymers to receive linear structure polymers where labile peptide bonds are preserved. To realize target-oriented synthesis of polymers and to determine reaction mechanism and optimal conditions of synthesis we studied the process kinetics and reaction regularities.

Some kinetic regularities of interaction of amide component and aldehyde were studied when the reaction was carried out in the solution at 50-70^{0}C at carbamide/formaldehyde molar ration 1:2, correspondingly.

Various factors affect the process of carbamide and formaldehyde interaction reaction. These are: process duration, temperature, molar ratio of starting components, amide component structure and composition, concentration of the solution. At the increase of temperature, conversion rate and reaction speed are increased. Thus, for example, after 15 minutes, conversion level at 50^{0}C reaches 29.23%, at 60^{0}C -43.58% while at 70^{0}C it reaches 71.79%. Besides the reaction length makes influence on the conversion level. Conversion level increases together with the reaction duration. Practically, reaction is completed in one hour.

We studied the effect of carbamide and

formaldehyde ratio on the reaction process. At the increase of formaldehyde quantity, conversion level and speed increase markedly. Already after one minute of the reaction carbamide-formaldehyde ratio equals to 1:2 mol and conversion rate is 5%. At the increase of this ratio up to 1:4, conversion level after 30 minutes increases from 60 to 77%.

Some kinetic regularities of the interaction of amide components and aldehyde in the solution were studied at constant temperature, at 50, 60 and 70^{0}C, when carbamide/formaldehyde ratio was 1:2. It was shown that reaction speed was increased with the increase of temperature and duration. 1-3 tables show kinetic parameters when the reaction was carried out at 50, 60 and 70^{0}C:

Table 1. *Kinetic parameters at the reaction carried out at 50^{0}C$^{x)}$*

t,min	x	a -x	a(a - x)	a(a -x)t	K, l/mol.sec.	P,%
1	0,00053	0,001892	3,6991· 10^{-6}	3,2194· 10^{-4}	2,3884· 10^{-1}	2,71
3	0,00015	0,00180	3,5100· 10^{-6}	6,3180· 10^{-4}	2,3741· 10^{-1}	7,69
5	0,00024	0,00171	3,3345 · 10^{-6}	10,0035 · 10^{-4}	2,3900 · 10^{-1}	12,30
10	0,00042	0,00153	3,9835 · 10^{-6}	17,9000 · 10^{-4}	2,3463 · 10^{-1}	21,53
15	0,00057	0,00138	3,6910 · 10^{-6}	24,2190 · 10^{-4}	2,3535 · 10^{-1}	29,23
20	0,00069	0,00126	3,4570 · 10^{-6}	29,4840 · 10^{-4}	2,3402 · 10^{-1}	35,38
25	0,0008	0,00115	3,2425 · 10^{-6}	33,6375 · 10^{-4}	2,37,83 · 10^{-1}	41,02
30	0,00088	0,00107	3,0865 · 10^{-6}	37,5570 · 10^{-4}	2,3431 · 10^{-1}	45,12
45	0,00108	0,00087	3,6965 · 10^{-6}	45,8055 · 10^{-4}	2,3578 · 10^{-1}	55,38
60	0,00122	0,00073	3,4235 · 10^{-6}	51,2460 · 10^{-4}	2,3806 · 10^{-1}	62,56
					aver. 2,3652 ·10^{-1}	

Table 2. *Kinetic parameters at the reaction carried out at 60^{0}C$^{x)}$*

t, min	x	a -x	a(a - x)	a(a -x)t	K,l/mol.sec.	P,%
1	0,00010	0,00185	3,6075· 10^{-6}	2,1645· 10^{-4}	4,6210· 10^{-1}	5,12
3	0,00026	0,00169	3,2955· 10^{-6}	5,9319· 10^{-4}	4,3837· 10^{-1}	13,33
5	0,00040	0,00155	3,0225 · 10^{-6}	9,0675 · 10^{-4}	4,4116 · 10^{-1}	20,51
10	0,00066	0,00129	2,5155 · 10^{-6}	15,0930 · 10^{-4}	4,3728 · 10^{-1}	38,84
15	0,00085	0,00110	2,1450 · 10^{-6}	19,3050 · 10^{-4}	4,4030 · 10^{-1}	48,58
20	0,00099	0,00096	1,8720 · 10^{-6}	22,4640 · 10^{-4}	4,4076 · 10^{-1}	50,76
25	0,00109	0,00086	1,6770 · 10^{-6}	25,1550 · 10^{-4}	4,3831 · 10^{-1}	55,89
30	0,00118	0,00077	1,5015 · 10^{-6}	27,0227 · 10^{-4}	4,3660 · 10^{-1}	60,51
45	0,00136	0,00059	1,1505 · 10^{-6}	31,0635 · 10^{-4}	4,3781 · 10^{-1}	69,74
60	0,00147	0,00048	9,3600 · 10^{-7}	33,6960 · 10^{-4}	4,3625 · 10^{-1}	75,38
					aver.4,4038 ·10^{-1}	

Table 3. *Kinetic parameters at the reaction carried out at 70^{0}C$^{x)}$*

t, min	x	a -x	a(a - x)	a(a -x)t	K,l/mol.sec	P,%
1	0,00028	0,00167	$3,2565 \cdot 10^{-6}$	$1,9539 \cdot 10^{-4}$	$14,3369 \cdot 10^{-1}$	5,12
3	0,00065	0,00130	$2,5350 \cdot 10^{-6}$	$4,5630 \cdot 10^{-4}$	$14,2450 \cdot 10^{-1}$	13,33
5	0,00089	0,00106	$2,0670 \cdot 10^{-6}$	$6,2010 \cdot 10^{-4}$	$14,3525 \cdot 10^{-1}$	20,51
10	0,00122	0,00073	$1,4235 \cdot 10^{-6}$	$8,5410 \cdot 10^{-4}$	$14,2840 \cdot 10^{-1}$	38,84
15	0,00140	0,00055	$1,0725 \cdot 10^{-6}$	$9,6525 \cdot 10^{-4}$	$14,5047 \cdot 10^{-1}$	48,58
20	0,00150	0,00045	$8,7750 \cdot 10^{-7}$	$10,5300 \cdot 10^{-4}$	$14,2450 \cdot 10^{-1}$	50,76
25	0,00158	0,00032	$7,2150 \cdot 10^{-7}$	$10,8225 \cdot 10^{-4}$	$14,5900 \cdot 10^{-1}$	55,89
30	0,00163	0,00032	$6,2400 \cdot 10^{-7}$	$11,2320 \cdot 10^{-4}$	$14,5121 \cdot 10^{-1}$	60,51
					aver.$14,3837 \cdot 10^{-1}$	

x) t –time in minutes, a-formaldehyde content in grams, at 100% conversion; x-formaldehyde quantity in grams, which is converted at this moment.

According to the Arrhenius K = AE – EA/ RT) number of molecules reacting in one second equals to a number of E cules atta second mu hat is $K = A \cdot e^{-\frac{E}{RT}}$, from it $lgK = lgA - \frac{E}{4,57T}$, where K is reaction speed constant, E-reaction activation energy, A- Arrhenius factor.

Volumes of reaction activation energy and probability factor are computed and E average= 7940.05 cal/mol = 7.94 kcal.mol. A = 0.0223 cal. mol*10 ^{2} l/mol.sec.

Effect of various factors, such as initial components molar ratio, amide component structure and composition, concentration was studied on the reaction of carbamide/formaldehyde interaction reaction. Reaction process is affected also by initial concentration of components. It is shown that increase of initial concentration of carbamide in reaction medium from 0.1 to 5 mol/l, increases reaction speed and conversion level. Thus, e.g. when initial concentration of carbamide is 0.1 mol/l, after 1 hour conversion level equals to 62.50%, when initial concentration is 1 mol/l – it is 66%, but when this concentration is 5 mol/l – conversion level equals to 78%.

The sequence of introduction of the initial components in the reaction area was studied. Carbamide is a multifunctional component and in case of simultaneous application of the initial components, a polymer with a spatial structure may be formed. When the aldehyde is gradually introduced into the reaction area the probability of reaction of aldehyde with the secondary hydrogen atom decreases, affecting the spatial structure of the polymer. When aldehyde is gradually introduced into the reaction area, there is always an excess of urea and the likelihood of the aldehyde reacting with the secondary hydrogen atom decreases.

It has been shown that by the increase of the initial concentration of aldehyde, the reaction rate increases.

Conclusion

The molar ratio of the initial components - carbamide and formaldehyde - greatly determines the chemical structure of the polymer obtained. When the molar ratio of the initial components - carbamide and formaldehyde is 1: 1,5-3,5, even when the pH is reduced to 4–4,5, it is possible to form a polymer with a spatial structure, which is highly undesirable for its use as a plastic material (due to poor flow which makes difficult its thermal treatment, it is also undesirable to use it as a fertilizer of prolonged action, since the period of adaptation and, consequently, that of biodegradation for degrading microorganisms is prolonged.

At such a ratio, methyl derivatives (mono-, di- and trimethyl derivatives) are formed at the initial stage of the reaction. Methylol groups are characterized by unstable and high reactivity. In the post-reaction phase, reactions may occur when the methylol group will react with the urea-free NH_2 group.

$-CH_2OH + -NH_2 \rightarrow -CH_2 - NH -$

Methylol groups interact with each other to form a dimethylene ether group, which then disintegrates.

$$-CH_2OH + -CH_2OH -CH_2 - O - CH_2 - \rightarrow -CH_2 -) + CH_2O$$

The methylol group interacts with the imine group. At this time a spatial structure is formed

$$-CH_2-NH- \; + -CH_2OH \longrightarrow -CH_2-\underset{|}{N}-CH_2-$$

As studies have shown, a high prolongation effect is achieved when the molar ratio of urea and formaldehyde is 1: 1. At this time a linear structure polymer is formed in which the peptide bonds (– CO – NH –) are retained.

The simplified structure of the linear polymer is expressed as follows:

$HNCONHCH_2 - [NHCONHCH_2]_n - HNCONHCH_2 -$

A study of the nature of the catalyst has shown that strong acids, such as sulfuric acid, hydrochloric acid, and phosphoric acid, accelerate the process much faster than formic or boric acids.

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The Monitoring of Wine Faults in Georgian Wines

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ABSTRACT

In this study, the results from two different wine tastings were compared. The first one contains the results of wine evaluations provided by the tasting commission of the National Wine Agency of Georgia for the exportation of commercial wines in 2019. These wines are mainly produced by large wineries according to conventional winemaking methods (sulphiting, different types of filtration, conservation and stabilization by additives, etc.); 7039 samples were tasted. The second one contains the results of wine evaluations performed by the tasting commission of the Tbilisi New Wine Festival for small family producers, held in 2019. The wines are mainly produced according to methods of non-conventional or traditional winemaking; a total of 575 samples were tasted.

One of the main goals was to review the whole picture of the Georgian wine market in terms of wine faults. Tastings and evaluation of wines produced by family and big commercial wineries were not carried out simultaneously. The data collected were processed by statistical means.

The tasting commission of the National Wine Agency of Georgia rejected 7% of the presented wines, because of oxidation, lack of typicity, and reductive wine faults. In the case of the festival wines, the rejection rate was 30%. The main reasons were mice flavor, oxidation, and elevated volatile acidity.

The hypothesis for a correlation between individual wine faults and a specific wine category has been confirmed, e.g., atypical ageing (ATA) had the most considerable rate in white wines. Also, bacterial faults have been shown in the segment of wines of small producers that use fewer preservatives for wine production.

The research showed that in contrast to the general opinion, for both - the industrial and the family wine segment, “mice flavour” dominated in white wines rather than in red ones.

Interestingly, wines produced in qvevri vessels had less microbial faults than those made in other vessels. It has also been proven that some defects are correlated with wine colour regardless of the production method; other faults are correlated with the production method regardless of wine colour.

Key words: Georgian wine, qvevri, wine faults.

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Introduction

Georgia is considered to be one of the oldest places in the world where viticulture and winemaking originated. According to archaeological research, pottery and some century-old tools were found and examined nearby the capital of Georgia at Shulaveri and Gadachrili Gora sites – the cluster of the agricultural settlement of the Shulaveri-Shomutepe culture. Excavated egg-shaped clay vessels, called *qvevri* in Georgia, provided chemical and archaeobotanical evidence of grapes dating back to the Neolithic period – 6000-5800 BC. [1]. According to proto-historical and archaeological findings, wild grape domestication took place in the Neolithic Age around 6000 BC., supposedly on the territory of South Caucasus, Northern Mesopotamia, Oriental Anatolia and Syria. Later it has been spreading to neighbouring regions and other parts of Eurasia [2, 3].

Most of the grape varieties cultivated on the territory of Georgia are indigenous. There are no confirmed data about the exact amount of autochthonous varieties. Still, according to the Ampelography of Georgia, there are 525 indigenous varieties [4], of which 414 described in the Ampelography of the Soviet Union (1947-1970) and only 248 remaining in old collections until 2003 [5]. Nowadays, more than 30 indigenous grape varieties are used for wine production. Among the most popular varieties are Saperavi (red) and Rkatsiteli (white), which are also cultivated outside Georgia.

According to the tradition, wine in Georgia has been made for centuries in amphora style clay vessels called *qvevri*, similar to the ones found at Shulaveri site. Other archaeological excavations also confirm that producing wine in *qvevri* has been popular during centuries from the Neolithic period until today. The *qvevri* vessel was mainly used for wine fermentation and storage. Even today this tradition is still practiced all around Georgia and getting more and more popular in other winemaking countries. The volume of *qvevri* vessels in Georgia varied from 20 L to 10,000 L, whilst today the most commonly ones used are of 500 – 2,000 L. Usually, the vessels are stored underground and covered with earth up to the very neck, thus ensuring stable temperature for wine maturation. Traditionally grapes (whites and reds) go to the vessel directly after crushing including grape skins, pips, and sometimes stalks. During alcoholic fermentation, the wine is enriched with phenolic compounds extracted from the solids (skin, pipes, stalks). This makes the difference between the Georgian classical method of winemaking and modern methods used worldwide where grape juice (usually whites and rosé) is drained from the solids and clarified before fermentation. After alcoholic fermentation *qvevries* are topped, sealed and covered with specific earth, and the wines are usually stored for approximately six months with all the solids and sediments but without sunlight exposure. During the ageing process, the phenolic compounds are partially oxidized and may turn the white wine colour from light golden to dark amber, sometimes associated with orange colour. For that reason, the name of this type of wines usually referred to as *Orange wines* worldwide, may confuse customers, mistakenly thinking that the wine is made from oranges or should be precisely orange in colour. There are plenty of people making wine at home in Georgia, mainly in villages where they pick the grapes from their vineyards or purchase them from growers. Sulphur dioxide and commercial yeast strains are not widespread and rarely used. Sometimes fumigation with sulphur dioxide is used to disinfect empty *qvevries* before filling them with crushed grapes. Today different types of wines are made in *qvevri*, some of them may contain just a part of grape solids during fermentation, and some others may exclude them totally [6]. As a proof of its cultural significance "The ancient Georgian tradition of qvevri winemaking" was assigned by UNESCO as National Monument of Intangible Cultural Heritage [7].

Aside from the famous 8000 years old beginnings, there are many other historical facts referred to by ancient authors: The famous Greek philosopher Xenophon (IV-V centuries BC) noted that Georgians drank wine undiluted and showed great love for dancing and singing. Another Greek philosopher Strabo, on the verge of a new and an old era, described Iberia (Eastern Georgia) and mentioned that the vineyards were so abundant that the population couldn't make use of the whole harvest. In the 6th century, the Byzantine historian Procopius of Caesarea noted that Georgians were making plenty of wine and were taking wine to other countries [8]. In the 4th century, with the spread of Christianity, the role of grapevine and wine increased and became more sacred, whilst Georgians combined their identity to grapevine and Christianity. In the 19th century, Georgia adopted the European style of winemaking, whilst also retaining its traditional method. Later under the influence of the Soviet system, Georgian winemaking turned towards mass production, falling in quality, and losing traditional values of *qvevri* winemaking, including loss of some of the indigenous grape varieties. With acquiring independence in the early 1990s, Georgian winemaking met a new reality and new requirements. Georgia adopted a system of Protected Designations of Origin and developed the Law of Georgia on Vine and Wine (1998) [9], quality control systems and technical regulations (2014) [10]. Beginning from the 2000s with great difficulties, the Georgian wine industry got out of stagnation, thus attracting the European market. The total area of vineyards is about 45,000 hectares, with more than 80% located in the eastern part of the country. According to Georgian legislation there are 25 wines with Protected Designation of Origin.

Today *qvevri* wines are of great interest in the world. The production of *qvevri* vessels as well as *qvevri* wines is increasing. Despite the high demand, some problems may influence sales and pose some risks for Georgian wine producers. In Georgia, family wineries are involved in the production of *qvevri* wines. Still, not all of them have high standards for proper maintenance of *qvevri* vessels and knowledge of modern techniques, resulting in wine faults such as microbial wine spoilage or physico-chemical disorders: mice flavour, volatile acidity, oxidation, *Brettanomyces*, malodorous volatile sulfur compounds, and others.

One of the goals of this study was the monitoring of Georgian *qvevri* wines for faults and off-flavours as commercialized in Georgia, including exported wines, to gain knowledge of the problems, thus creating the basis for future research towards improvement of *qvevri* wine quality and food safety.

Literature Review

Most of the wine faults have only sensory importance and can't cause serious problems for human health. Nevertheless, it's essential to differentiate original tastes and aromas from off-flavours caused by microorganisms or physico-chemical mechanisms. Today there is an extraordinary amount of high-quality wines in the world that makes the competition for sales stricter, thus developing quality control systems, researching tastes, aromas, and their constituting compounds. Significant influence on wine aroma has oxygen. Depending on the rate of exposure, oxygen may differentiate wines in both high and low quality wines, having great importance for consumer acceptance and preference. Too little or too much oxygen can influence the appearance of serious faults during vinification and ageing with the formation of excessive concentrations of compounds responsible for oxidative or reductive off-flavours. Usually, the oxidation of wine takes place through a cascade of reactions in which oxygen, in combination with oxidation catalysts such as iron and copper, leads to the formation of free oxygen radicals (highly reactive chemical compounds) and peroxides, which can, in turn, react with other wine compounds [11]. When phenolic compounds are oxidised, wine may turn amber or brown, changing aroma as well. The oxidation of ethanol, resulting in acetaldehyde, is usually associated with the odour of bruised apples or sherry. Some of the aerobic film-forming yeasts such as *Candida sp., Pichia sp*., *Hansenula sp., and S. ludwigii,* in the presence of air, can convert excessive amounts of wine ethanol into acetaldehyde, through a reaction catalyzed by the enzyme ethanol-dehydrogenase. Acetic acid bacteria can also produce acetaldehyde by the decarboxylation of pyruvate. According to some of the researches, the sensory threshold for acetaldehyde is about 100–125 mg/L [12]. However, according to Schneider [13] only the free form of acetaldehyde (not bound to sulphur dioxide), is sensorially active. Schneider shows that as little as 1 mg/L of free acetaldehyde which only occurs in the absence of free sulphur dioxide, can be perceived as faulty by smell. Free acetaldehyde and free sulphur dioxide exclude one another.

Along with spoilage yeasts, acetic acid bacteria may change wine quality dramatically resulting in increased levels of acetic acid, commonly referred to as volatile acidity (VA) with an odour reminiscent of vinegar. The film-forming yeasts and acetic acid bacteria normally require oxygen for growth. For that reason, oxidation and VA increase in wines are usually associated with a lack of hygiene and untopped vessels providing headspace oxygen – ideal conditions for germ development. In the case of acetic acid bacteria development, the enzyme alcohol dehydrogenase oxidizes ethanol to acetaldehyde that is further oxidized to acetic acid by the enzyme aldehyde dehydrogenase. According to Du Toit and Pretorius [14], acetic acid bacteria occur as four genera: *Acetobacter*, *Acidomonas*, *Gluconobacter*, and *Gluconoacetobacter*. *Acetobacter* is mainly found in fermented substrates, such as wine, beer, whilst *Gluconobacter*is is mainly associated with sugar-rich environments like grapes and other fruit. The legally acceptable upper limit for volatile acidity in most wines is 1.2 g/L of acetic acid [15], the aroma threshold depends on the wine style. VA concentration of 0.90 g/L can produce a slightly bitter, scratchy and sour aftertaste in wine, still without a strong odour [16], although concentrations as low as 0.6 g/L may be perceived as faulty in many wines. Commonly the "acetic nose" is due to ethyl acetate that is one of the metabolites of acetic acid bacteria. However, less ethyl acetate is produced under low oxygen conditions [17]. Yeast strains of the species: *P. anomala, Kloeckera apiculata, Hanseniaspora uvarum, Metschnikowia pulcherrima* and others along with acetic acid bacteria can form an ester taint in wines with glue-like aroma at the initial stages of alcoholic fermentation [18], especially if it is present in concentrations above 100–200 mg/L

[19]. Wine spoilage may also be related to other types of yeasts such as *Dekkera/Brettanomyces* that is frequently found in wineries. When it contaminates wines, it may result in undesirable metabolites referred to as volatile phenols, in particular 4-ethylphenol (4-EP), 4-ethylguaiacol (4-EG) and 4-ethylcatechol (4-EC). The odours of these compounds in wines are described as: "clove," "spicy," "smoky," "leather," "cedar", "medicinal," "band-aid," "horsy," "wet wool," "barnyard," sometimes even "sewage" [20,21]. These volatile compounds are the decarboxylation products of phenolic acids (trans-ferulic and trans-*p*-coumaric acid) [22]. *Brettanomyces* is not the dominant yeast during alcoholic fermentation; however, it can be found after 6–10 months of storage [23]. During wine ageing in oak barrels with some dissolved oxygen, low levels of sulphur dioxide and relatively high temperature provide good conditions for *Brettanomyces* successfully growing, resulting in sensory wine defects. It is supposed that this yeast may develop in the period between the end of alcoholic and the beginning of malolactic fermentation [24], though its development can also occur after several months of additional storage, in particular in wooden barrels. Furthermore, it is thought that "Brett character" may occur even after bottling in minimally filtered wines [25]. *Brettanomyces* develops especially in red wines due to the high level of phenolic acids that are derived from grape skins during alcoholic fermentation. Its perception threshold may vary. According to Loureiro and Malfeito-Ferreira [26], 4-EP over 620 μg/L may be found unacceptable by some consumers. If the concentration does not exceed 400 μg/L, this compound sometimes may be described as "spice," "leather," "smoke," or "game." According to Licker et al. [27], "high Brett level" wines contained 3,000μg/L of 4-EP. Fugelsang and Zoecklein [28] reported that the relative amounts of volatile phenols might differ according to *Brettanomyces* strains involved. 440 μg/L of 4-EP and 120 μg/L of 4-EG were produced by one strain, whilst another strain accumulated just <10 μg/L. Besides "Brett character", *Dekkera/Brettanomyces* yeast may develop an offensive odour reminiscent of rodent cage or rabbit hutch litter, the so-called "mousy" taint. It is supposed to appear in wine due to the metabolism of amino acids such as lysine and ornithine, resulting in the formation of heterocyclic nitrogen compounds: 2-acetyltetrahydropyridine (ACTPY), 2-ethyltetrahydropyridine (ETPY), and 2-acetyl-1-pyrroline (ACPY) responsible for the offensive odour [29]. Apart from *Brettanomyces*, the growth of some strains of lactic acid bacteria (*L. brevis*, *L. hilgardii*, and *L. cellobiosus*) may also cause the production of "mousy" odours in wines [30,31]. Interestingly, it is almost impossible to smell the "mice" off-flavour. Only after swallowing the wine, the alkaline nature of saliva neutralizes wine acidity, thus releasing ACTPY and related compounds [32] recognized in the pharynx (retro-nasal area) as a persistent unpleasant aftertaste [33]. According to Sponholz [34], it is possible to identify "mice flavour" after rubbing a few drops of the infected wine between palms and smelling them fast afterwards. This fault develops mainly in wines rather than in musts because ethanol is required for the synthesis of these compounds [30]. The perception threshold of the "mousy" compounds, according to Riesen [35], is extremely low (1.6 μg/L). Therefore, very little activity of the bacteria may influence the wine spoilage. Mousiness is not a prevalent problem. It could be related more to some low-acidity wines with lack of sulphur dioxide [34]. According to Lay [36] different *Brettanomyces* cultures may form "mice flavour" in wine in the presence of the corresponding amino acids.

The importance of lactic acid bacteria [LAB] in winemaking is very high. Malolactic fermentation [MLF] induced by several species of lactic acid bacteria may provide a natural deacidification of wines. The total acidity decreases due to degradation of the dicarboxylic L-malic acid into monocarboxylic L-lactic, developing some secondary products. MLF can influence wines' microbial stability [37,38], but improper management of the process may decrease wine quality resulting in different wine faults [39]. Usually, MLF takes place at the end or after alcoholic fermentation when a low concentration of hexoses and pentoses may still exist in the wine. According to a heterofermentative or homofermentative pathway, the LAB of the genera *Lactobacillus, Oenococcus* and *Pediococcus* may assimilate sugars resulting in undesirable metabolites. The obligatory heterofermenters (*Oenococcus oeni, Lactobacillus brevis, Lactobacillus hilgardii*) degrade sugars into lactic acid, ethanol and acetic acid, the latter resulting in a VA increase, sometimes to unacceptable levels. Some of the homofermentative *Pediococcus* species transform nearly all of the hexoses into lactic acid according to the Emden-Meyerhof pathway [40,41]. Assimilating sugars through the homofermentative and heterofermentative pathway, LAB may produce a mix of undesirable end products.

One of the most important off-flavour compounds produced by LAB is diacetyl or 2,3 butandione with a distinct buttery odour [42,43]. The LAB species: *O. oeni, L. plantarum*, *L. mesenteroides,* and *L. casei* can efficiently metabolise citric acid producing diacetyl. Its perception threshold may vary according to the wine type [44]. According to Rankine et al. [45], low concentrations of diacetyl may be desirable in some types of wines, as the amount 1-3 mg/L of diacetyl results in "nutty" or pleasant "buttery" aroma, whilst a concentration above 5-7 mg/L gives an unpleasant spoiled "buttery" odour. Along with citric acid degradation, diacetyl can also be produced by homolactic or heterolactic pathways of sugar metabolism [46]. Many factors influence the concentration of diacetyl in wine. One of them is the strain factor: *Ooenococcus oeni* may produce relatively lower concentrations than *Lactobacillus and Pediococcus* [47,48]. Another factor is the reduction of diacetyl to odourless butanediol by suspended post-fermentation yeast cells.

Some species of LAB can produce off-flavour compounds from preservatives such as sorbic acid that is sometimes used in wine to prevent residual sugar from refermentation after bottling. Sorbic acid (2,4-hexadienoic acid) is reduced to sorbitol through hydrogenation; then it is isomerised to alcohol 3,5-hexadiene-2-ol reacting with ethyl alcohol forming 2-ethoxyhexa-3,5-diene, the compound that has an offensive crushed geranium leaves odour [49] with a sensory threshold of about 100 ng/l [35]. With the development of sterile filtration and sterilization equipment, it became possible to prevent bottled wines with residual sugar from refermentation without addition of sorbic acid, thus avoiding risks for geranium taint production.

LAB can contribute to reductive off-flavour by breaking wine amino acids into volatile sulphur compounds. The *Oenococcus oeni* species may convert the amino acid cysteine into hydrogen sulfide and 2-sulfanyl ethanol, and methionine into dimethyl disulfide and other products [41]. Dimethyl disulfide gives cabbage, onion-like odours, whilst hydrogen sulfide has an odour reminiscent of rotten eggs, burnt match. It may also occur during nitrogen deficiency [50] in the process of alcoholic fermentation and act as a precursor for mercaptans [51].

Among other off-flavours, great attention is paid to "mouldy", "earthy", mushroom-like odours that occur in wine during different mould species multiplication. *Penicillium expansum* can synthesise geosmin, an earthy-muddy smelling compound with a sensory threshold of 30 to 50 ng/L. [52]. *Trichotecium roseum*, *Aspergillus* section *nigri*, and several species of *Penicillium* may influence the production of 1-octen- 3-one, a compound with a fresh mushroom flavour [53].

One of the most common wine faults that occurs explicitly in white wines is the "atypical ageing off-flavour" (ATA), sometimes referred to as UTA ("Untypische Alterungsnote") according to German terminology. The naturally occurring phytohormone indole-3-acetic acid is chemically degraded leading to the formation of 2-aminoacetophenone with an odour reminiscent of naphthalene, wet wool, floor polish, fusel alcohol, acacia blossom. This odour mainly occurs within a few days or several months after alcoholic fermentation and the addition of sulphur dioxide, the latter triggering the reaction [54]. This happens due to stress factors in the vineyard, such as insufficient water or nitrogen supply, as well as high yield and premature harvest [55].

Other problems of non-microbiological character may be mentioned. High levels of sulphur dioxide may interfere wine quality, eliciting a pungent smell and a harsh, metallic aftertaste.

The literature contains data from studies conducted at different times, which show that the wine industry of other countries faces more or less common problems.

Wines rejected by the Austrian State Tasting Commission during 2013 are presented in the following percentage ratio: reductive faults (mercaptans, hydrogen sulphide) - 32.2 % , moldy and earthy faults (including cork taint) - 30.3%, oxidation - 22.4%, lack of body - 9.2%, *Brettanomyces* - 5.3%, bitterness, sharpness - 4,6%; diacetyl - 4,6% [56].

As a result of the 2008 International Wine Challenge, 6% of the wines from about 10,000 samples were rated as faulty; the most common problems were cork taint or mouldy odour with 31%, reductive faults – 29%, oxidation – 19%, *Brettanomyces* – 16% [57].

Materials and Methods

The industrial wineries presented at the National Wine Agency tastings work according to the Law of Georgia on Vine and Wine [9] relying on the standards and regulations of the International

Organisation of Vine and Wine [58]. The sensorial evaluation of the wines is a part of the standard procedure for providing export authorization with the aim of controlling and maintaining quality standards. The sensorial evaluation is provided for the wines to be exported except for the wines produced by small family wineries (definition given in the Law of Georgia on Vine and Wine).

According to the amendments to the Law of Georgia on Vine and Wine (#2-82 from19.02.2018), wine sensorial evaluation has become mandatory for all wines to be exported since January 1, 2018.

The Wine Tasting Commission was created in 2007 with the cooperation of GIZ (German Cooperation for International Cooperation GmbH) within the frames of the program promoting the development of Georgian wine quality.

The evaluation system was developed based on the experience of the German DLG system. The members of the tasting commission have undergone extensive training and passed the final qualification examination. Each taste panel was composed of 5 members of the tasting commission (based on the principle of rotation) with the head of the tasting commission monitoring each tasting.

The German DLG system can be described as follows: Wine is rated on a 5-point scale that was introduced according to ISO- Norms [59]. ISO- Norms (https://www.iso.org/) regulate the vocabulary to use in sensory science (ISO 5492:2008) [60] as well as about designing a sensory test (ISO 6658:2017) [61] and the equipment being used (ISO 3591:1977 e.g. for wine testing) [62]. Sensory science distinguishes between tests where untrained people can give their opinion (e.g. preference tests; ISO 11136:2014 / AMD 1:2020) [63] and more objective tests run by trained panelists (ISO 8586:2012; ISO/CD 8586; ISO 11132:2012) [64,65,66]. The regulations incorporate how to design the specific tests as well as who to perform the statistics (e.g. ISO 29842:2011 /AMD 1: 2015) [67].

The wine testing according to DLG was established following German testing guidelines in order to describe German wines by trained panelists (DIN-Norm 10952) [68,69]. They have to score "blind" wine samples (not naming them) on a 5-point-scale and shortly describe the characteristics of the wines. A score of less than 1.5 points means rejection of the wine, in this case at least one fault or a general lack of minimum quality must be indicated. The following list indicates the reasons for possible rejection on the basis of faults: oxidation, volatile acidity (VA), reductive odours (H_2S, mercaptans), *Brettanomyces*, diacetyl, mice flavour, earthy/mouldy smell, geranium odour, excessively high free sulphur dioxide level, atypical ageing (ATA), lack of typicity.

If the wine has any unlisted fault or cannot be accurately categorised, then the rejected wine will be related to the category –"other". The tasting is carried out on weekdays on a daily basis or depending on the number of samples with a maximum of 54 samples to be tasted during the session.

Tbilisi New Wine Festival has been held since 2010. This is the largest and most popular event in Georgia for wine lovers. The festival presents mainly small enterprises and family wineries, all of them have to pass the tasting control to be allowed to the festival. Qualified wine tasters from the National Wine Agency of Georgia are invited to evaluate the wines according to the methods used in the National Wine Agency with the same possible reasons for wine rejection. The rejected wines are marked with one or more wine faults and recorded.

Chi-Square Test of Independence was carried out for statistical processing of the data to check whether the respective categories are related to each other. The P - value is presented in the end of each comparison of the categories.

Results

The NWA tasting data include records from 183 evaluation meetings provided during the first 9 months of 2019. In this context, 510 wine samples were rejected from evaluated 7039 wines. The presented wines are divided into the following categories: white dry, white with residual sugar (semi-sweet, semi-dry), white AOC (controlled designation of origin) wines, red dry, red with residual sugar, red AOC, red AOC with residual sugar, "amber" wines (fermented with skin contact including *qvevri* wines). In Table 2, the main 11 wine faults are specified, whilst all other faults are grouped in the category "other" due to a statistically insignificant amount.

The tasting commission of the 2019 Tbilisi Wine Festival provided a preliminary wine evaluation resulting in 575 tasting protocols with 175 wines rejected with one or several faults. In Table 4 seven main wine faults are displayed, whilst all other faults are assigned to the category "other" due to their lack of identification.

Discussion

The presented tables show the results of the wine tastings performed with two different goals. The Tables 1 and 2 contain the results of tastings of the wines from big industrial wineries intended for exportation as provided by the tasting commission of the National Wine Agency of Georgia (NWA). The Tables 3 and 4 present data for the wines trying to qualify for the festival where mainly family wineries, i.e. small enterprises are presented. Along with the main goals of the tastings and according to the results, it is possible to distinguish two different segments of wine production: (i) industrial wine production, working mostly conventionally, and (ii) small, family winemaking, primarily working according to the methods of so-called "natural winemaking" where industrial methods (sulphiting, different types of filtration, conservation and stabilization by additives, etc.) for wine treatment are totally excluded or minimized.

The number of wines evaluated at the NWA is 7039, the number of those submitted for the festival – 575.

In total, 7% of the samples submitted to the NWA tasting and 30% of the festival wine samples were rejected. This ratio may be considered logical because the NWA wines were produced by professional winemakers and controlled according to internal and international standards including tastings prior to bottling.

The largest number of rejected wines from the NWA tastings is caused by oxidation with 41% of the total of rejected wines, followed by lack of typicity – 19%, reductive taint (hydrogen sulfide, mercaptans) – 12%, VA (volatile acidity) - 10%.

Among the rejected wines from the festival, mice flavor has 34%, VA - 31%, oxidation – 22%, diacetyl – 15%, musty/mouldy taint – 11%.

As expected, some faults were detected only in the wines produced according to the conventional methods, e.g., geranium odour - the sensory problem caused by microbial degradation of the preservative potassium sorbate. The category "lack of typicity" is relevant only for AOC (controlled designation of origin) wines and the ones produced according to the established technological standards, its rejection has a fairly high rate. In contrast, the festival wines have no preliminary definition of typicity, therefore the category "lack of typicity" is not used during the evaluation of the festival wines. Theoretically, wines from non-conventional wineries could be rejected due to "atypical ageing" (ATA), although there was no sample with this problem detected at the festival qualifying tasting in 2019. The low rate of rejected *amber* (skin contact, whether from *qvevri* or another vessel) wines in the industrial segment is significant: *amber* – 2%, other – 7% (P=0.001), whilst almost no significant difference is observed within the festival wines: *qvevri* - 28%, non-*qvevri* – 32% (P=0.19). *Qvevri* wine for industrial wineries is less commercial and carries more prestigious character undergoing special care and treatment. For family wineries, *qvevri* wine sometimes is a standard product.

Along with the above-mentioned problems exclusively encountered in industrial wines, the comparison of different wine faults exhibits other essential distinctions between industrial and family wines. According to Figure 1, oxidation (acetaldehyde) in faulty NWA wines is almost twice as much (41%) as in faulty festival wines (22%), (P<0.001). There is no objective precondition for this due to technological differences, as both groups of wines have a comparable risk of oxidation or comparable protection against oxidation. Traditionally, e.g., *qvevri* wines hold a big part of small (family) enterprises production, in which the methods usually comprise longer contact with lees and the abundance of phenolic compounds resulting from fermentation on grape solids - skins, seeds, and sometimes stems. Consequently, they may show antioxidant properties even with less SO_2. On the other hand, the largest part of industrial wines is presented as non-*qvevri* wines, with less antioxidant properties but protected more by the addition of higher amounts of SO_2 post-fermentation. In both situations the level of antioxidant stability relies on the skills and preferences of winemakers that may finally influence the quality of both categories to the same extent. In this case this fact may be explained by more tolerance towards oxidised wines produced by family/small enterprises during the wine evaluation. The problem here is more tolerated than in conventional - NWA wines that are mainly exported. If one compares the technological facilities of industrial and small wineries, the results should not diverge in this way. It is difficult to say that one production method is much safer than another. However, if the tasting reports included the analytical data of free SO_2, which is not the case, more conclusions could be drawn.

The amount of reductive faults in faulty NWA wines is not significant - 12% compared to 8% of festival samples (P = 0.11).

All other faults of microbiological origin occur in festival wines to a greater extent with significant difference and are discussed further below:

Wine spoilage due to aerobic bacteria, resulting in high volatile acidity, was observed in 31% of all rejected festival wines, whilst the same problem was observed in only 10% of all rejected NWA wines (P<0.001). The reason may partially be related to the fact that industrial wines undergo two stages of control before NWA evaluation: inner and external laboratory check for chemical composition. In contrast, in the case of festival wines (small enterprises), only sensory assessment is performed.

Wine spoilage due to lactic acid bacteria (LAB) resulting in malodorous diacetyl levels was observed in 15% of all rejected festival wines, whilst for NWA wines it was 2% (P <0.001).

Mice flavour caused by LAB was 34% of all rejected festival wines and 5% for NWA wines (P<0.001).

Sensory problems usually related to *qvevri* maintenance and hygiene resulting in a musty/ mouldy fault were identified in 11% of all rejected festival wines, but for NWA wines they were only 6% (P =0.046).

Analysing the difference between the categories of the industrial wines, it becomes evident that the highest rate of rejected samples is 15% in the AOC wines with residual sugar. This is much higher than the average of 7% (P <0.001), even though in this type of wines the risk of bacterial spoilage is much lower than in dry wines having undergone malolactic fermentation. Indeed, there is only 5% of all microbiological faults in the rejected AOC wines with residual sugar in contrast with 34% of all other rejected wines (P <0.001). A high rate of rejected AOC wines with residual sugar can be explained by the "lack of typicity" that is exceptionally high - 36%, whilst in other wines this problem is less than 10% (P <0.001). "Lack of typicity" is related to the lack of varietal and fruity aromas that should be typical for a certain wine.

There could be found a tremendous difference in other wines as well. For example, white AOC wines were rejected due to ATA in 28% of all rejected samples, whilst the rate of this fault in other white wines was around 2% (P <0.001). This can be explained by the fact that other white wines may contain more phenolic compounds due to the use of higher amounts of press fractions or due to a more prolonged skin contact period. Indeed, phenolics are supposed to mitigate the appearance of ATA [54]. Conversely, AOC wines contain less phenolic compounds due to the limited usage of press fractions or less skin contact. In the case of oxidation, the ratio is 52% for AOC white wines to 27% of other white wines (P=0.014). This fact may be related to the poor stability of free SO_2 and its decrease by oxygen uptake during bottling and bottle storage.

As it is usually described in the literature, *Brettanomyces* is mainly a problem of red wines, in NWA wines it shows as follows: red dry – 16%, red dry AOC – 13%, red with residual sugar – 9%, whites - not detected. In the case of mice flavour, the results show that this fault is mainly associated with white wines, as this fault was observed in 14% of all rejected white wines, whilst in reds the number was 3% (P<0.001). This may be a coincidence, as there is no plausible reason for it.

The evaluation of wines presented for the wine festival showed that the faults are not associated with a specific category of wine, but there was a clear relationship between the wine fault and paired categories. The pairings are based on the colour and the wine production method.

The 4 categories indicated in the festival wines are:

White non-*qvevri* wine

White *qvevri* wine

Red non-*qvevri* wine

Red *qvevri* wine

These categories were paired as follows:

All white wines vs. all red wines;

Qvevri wine of both colours vs. non-*qvevri* wine of both colours.

In Figure 2, as a reference, there is an average indication for all wines.

The grouping of the four categories of wines from the Tbilisi Wine Festival tastings gives an excellent opportunity to compare wines according to colour and production method. Categories resulting from the Tables 3 and 4, after grouping show the following:

Reductive notes are noticeably higher in non-*qvevri* wines - 12% than in *qvevri* wines - 4% (P <0.049). This might be related to the lower oxygen uptake in non-qvevri wines, which are frequently stored under anoxic conditions in stainless steel vessels. Colour has no influence: non-*qvevri* - 7% to *qvevri* - 10% (P <0.45).

As expected, *Brettanomyces* is more common in red wines (17%) than in whites (1%) (P <0.001), whilst the production method has no influence – *qvevri* - 6% to non-*qvevri* - 9% (P <0.56).

Mice flavour is more common in white wines – 41% than in reds – 24% (P=0.017). Similar results were shown by the NWA tasting commission. There is an assumption that *qvevri* wines are more infected by mice flavour than non-*qvevri* wines, although the difference here is not significant. Moreover, mice flavour was found in 31% of *qvevri* wines, non-*qvveri* - 38% (P =0.30).

In the case of diacetyl, no correlation was found between colours (P=0.52) or production methods (P = 0.65). All results were close to average.

A musty or mouldy fault is related to the *qvevri* technology -19%, non-*qvevri* - 1% (P <0.001) with no relationship to the wine colour: red – 13% to white - 8% (P = 0.18). This phenomenon might be related to the difficulty of properly sanitizing *qvevri* vessels.

Volatile Acidity (VA) for wines not fermented in *qvevri* was 38%; for wines fermented in *qvevri* – 26% (P = 0.07). Colour has no influence as well: red - 30%; white - 34% (P = 0.57).

Oxidation for white wines – 25%; for reds – 18% (P = 0.29).

Vessels type has no influence as well: *qvevri* - 24%, non-*qvevri* - 20% (P = 0.45).

Table 1. *Georgian National Wine Agency – results of the 2019 wine tasting as a percentage of faulty wines according to wine category.*

Type of Wine	White			Red				Amber	Total
	Dry	R.S. [1.]	AOC [2.]	Dry	R.S.[1.]	AOC[2.]	AOC R.S.		
Number of tested samples	458	1036	559	1281	1654	544	1286	221	7039
Number of faulty wines	33	52	29	90	91	24	187	4	510
% of faulty samples	7	5	5	7	6	4	15	2	7

1. R.S. – Wines with residual sugar; 2. AOC – wines with controlled designation of origin.

Table 2. *Georgian National Wine Agency – breakdown of wine faults found in the 2019 tasting.*

№	Type of wine	White						Red								Amber	
		Dry		R.S.		AOC		Dry		R.S.		AOC		AOC R.S.			
	Number of faulty wines	33		52		29		90		91		24		187		4	
	Wine faults[3.]	№	%[4.]	№	%	№	%	№	%	№	%	№	%	№	%	№	%
1	**Volatile acidity, ethyl acetate**	1	3	4	8	1	3	24	27	14	15	2	8	1	1	3	75
2	**Oxidation, acetaldehyde**	11	33	12	23	15	52	40	44	42	46	11	46	75	40	2	50

3	**H_2S, mercaptans**	8	24	13	25	2	7	10	11	13	14	2	8	15	8	0	0
4	**Brettanomyces**	0	0	0	0	0	0	14	16	8	9	3	13	3	2	0	0
5	**Diacetyl**	0	0	3	6	0	0	5	6	1	1	1	4	1	1	0	0
6	**Mice flavor**	5	15	8	15	3	10	2	2	6	7	1	4	2	1	0	0
7	**Mouldy odour**	4	12	2	4	1	3	7	8	6	7	2	8	9	5	1	25
8	**Atypical ageing**	1	3	1	2	8	28	0	0	0	0	0	0	0	0	0	0
9	**Lack of typicity**	3	9	2	4	8	28	9	10	4	4	3	13	68	36	0	0
10	**Extra SO_2**	0	0	1	2	0	0	1	1	1	1	0	0	0	0	0	0
11	**Geranium odour**	0	0	0	0	0	0	0	0	1	1	0	0	2	1	0	0
12	**Other or unidentified off-flavours**	7	21	11	21	2	7	13	14	17	19	0	0	16	9	1	25

3. Wines can show one or more faults; 4. Percent of samples

Table 3. *Tbilisi Wine Festival – results of the 2019 wine tasting as a percentage of faulty wines according to wine category.*

Type of Wine	**White**		**Red**		**Total**
	Non qvevri	Qvevri	Non qvevri	Qvevri	
Number of tested samples	117	218	126	114	575
Number of faulty wines	44	60	37	34	175
% of faulty samples	38	28	29	30	30

Table 4. *Tbilisi Wine Festival – breakdown of the wine faults found in the 2019 tasting.*

#	**Wine Faults**	**White**				**Red**			
		Non-qvevri		**Qvevri**		**Non-qvevri**		**Qvevri**	
	Number of faulty wines	44		60		37		34	
	Wine faults	№	%	№	%	№	%	№	%
1	**Volatile acidity, ethyl acetate**	16	36	15	25	15	41	9	26
2	**Oxidation, acetaldehyde**	10	23	16	27	6	16	7	21
3	**H_2S, mercaptans**	5	11	2	3	5	14	2	6
4	**Brettanomyces**	0	0	1	2	7	19	5	15
5	**Diacetyl**	5	11	9	15	6	16	6	18
6	**Mice flavor**	19	43	24	40	12	32	5	15
7	**Mouldy odour**	1	2	13	22	0	0	5	15
8	**Other or unidetified faulty off-flavours**	7	16	11	18	9	24	11	32

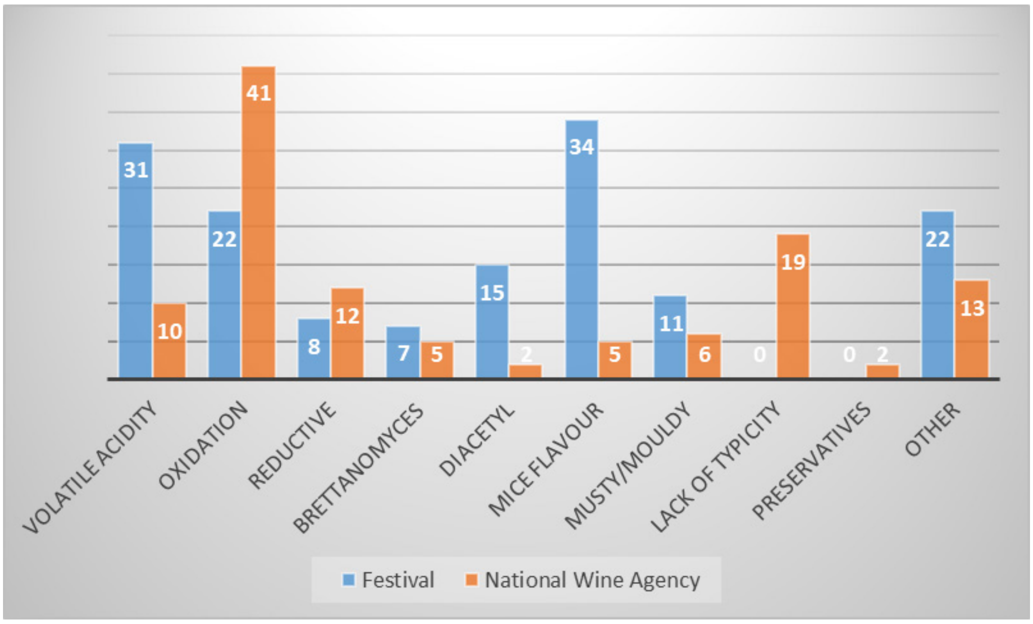

Figure 1. Comparison (in %) of wine faults identified by the Festival and the National Wine Agency.

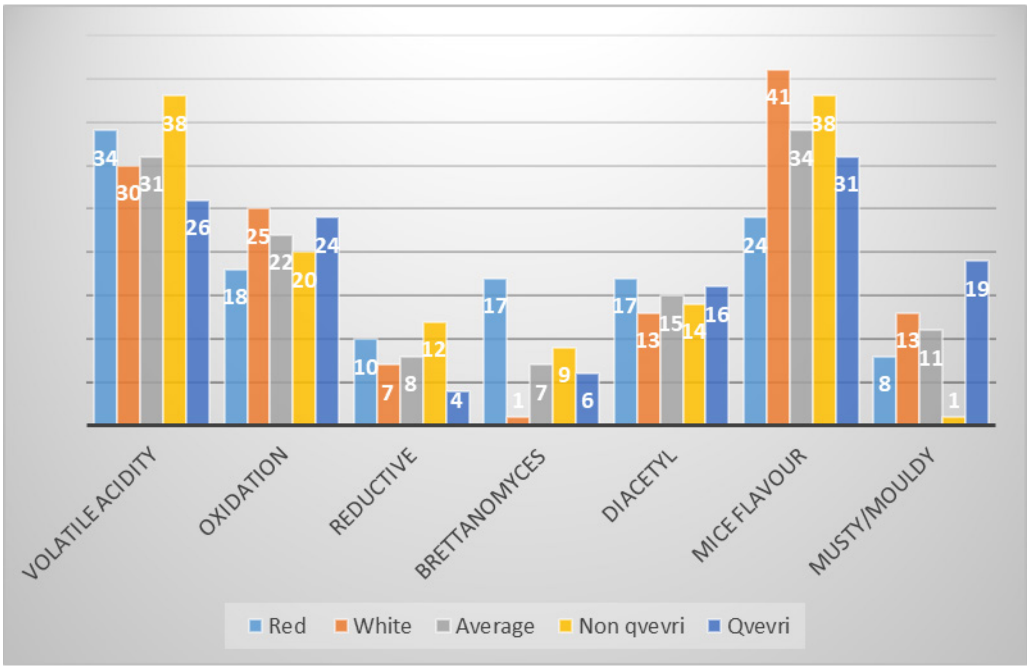

Figure 2. Tbilisi Wine Festival wines: Breakdown (in %) of the wine faults identified in the 2019 tasting. comparison according to categories (%)

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The Chemical Erosion in River Basins of Georgia

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A B S T R A C T

Soil erosion events in the river basins of Georgia are quite intense in both the middle and upper reaches of the western and eastern Georgian rivers, with soil leaching 10-33 t/ha per year. Especially with high denudation, 0.8-1.0 mm annually are characterized by watersheds of western Georgia: Kodori, Enguri, Mananga, Techuri, Rioni, Kvirila, Adjaristskali and Satsikhuri watersheds. From the rivers of western Georgia - the river.i Kodori (Vil. Latha - 6.60 t/ha), Enguri (Vil. Dizi - 6.30 t/ha), Rioni (Vil. Khidikari - 6.10 t/ha, Vil. Namokhani - 6.50 t/ha). From the rivers of western Georgia - the river Kvirila (Zestafoni - 6.90 t/ha) and Adjaristskali (Khulo - 6.50 t/ha), solid runoff module exceeds the permissible amount of erosion. The watersheds of the Southern Georgian Rivers basin are characterized by minimal denudation that varies from 0.01 to 0.08 mm per year. This denudation of the watersheds of the rivers of southern Georgia can be termed "geological erosion". Ionic runoff accounts for 15-88% of total runoff. Ionian runoff in sediments in southern Georgia exceeds sedimentary runoff, which is not observed in river basins of other regions of Georgia.

Key words: Soil erosion, Watersheds, Sedimentary runoff, Suspended sediments, Chemical runoff, Arable soils.

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Introduction

There is no data on assessing the intensity of manifestations of soil erosion processes in various natural conditions in Georgia, which would at least partially cover a significant part of the country's territory. There are only fragmented experimental data that describe the identification and intensity of the development of erosion phenomena. The above materials that have accumulated in soil-erosion data describe the identification of erosion processes on agricultural land in both Western and Eastern foothill-hilly [1,2] and mountain-forest zones [1-7]. Data There were, of course, on the amount of chemical elements dissolved in water, but no quantitative analysis of soil erosive events has been carried out so far and therefore no regularity has been established for the conditions in Georgia.

Objects and research methods

Based on hydrological data, the intensity and spatial variability of erosion processes in the main catchment areas of the Georgian rivers were analyzed. To solve this problem, we used the mean long-term data of runoff and turbidity of river waters. The amount of runoff and suspended sediment was determined with actual data on observations of the turbidity of river waters

[8.9], and for rivers and tributaries that have not been studied in this respect, according to the dependences are given in [10]. According to the above dependencies and according to the data on the mean annual discharge of water, it is possible to determine the average annual discharge of suspended sediment in rivers, in kg/s.

The average annual runoff of suspended soil particles that enters river water from one hectare of arable land located in its catchment basin is calculated taking into account the fact that as a result of erosion only 15-20% of the total washed out from the slopes of the soil enters river water [11, 12].

In the foothill-hilly and low-mountain zone of Georgia it was experimentally established that only 17-20% of the total mass of washed away soil particles from the arable land located on the slopes as a result of erosion processes [5]. Therefore, for the conditions of Georgia, as a mountainous country, one should take a 20% level of getting into the river waters washed away from the sloping arable land of soil particles.

Chemical runoff data from river catchments were taken from the bulletins of the Hydrometeorological Department of Georgia [13].

The results obtained and their discussion

As the area of arable soils increases, especially in the foothill and mid-mountain zones, the area of eroded soils increases. In Western Georgia, the area of arable land is 2.5 times less than in Eastern Georgia. Nearly 34% (63.0 thousand ha) of arable land is eroded to varying degrees in Western Georgia, and 29.0% (142.7 thousand ha) in eastern Georgia. Across Georgia, the area of weakly eroded arable land is 110.5 thousand ha (16.4%), medium eroded - 74.4 thousand ha (11.0%) and highly eroded - 20.8 thousand ha (3.1%) (Table 1).

Table 1. *The area of eroded arable soils of Georgia*

Administrative division of Georgia	Total arable land		Including eroded						Sum	
			Weak		Average		Heavy			
	thous. ha	%	thous. ha	%	thous. ha	%	thous. ha	%	thous. ha	%
Regions of Western Georgia	141,9	100	24,0	16,9	15,5	10,9	6,1	4,3	45,6	32,1
Abkhazian A.R.	36,1	100	3,7	10,2	5,3	14,7	3,1	8,6	12,1	33,5
Adjara A.R.	8,8	100	2,7	30,7	2,5	28,4	0,1	1,1	5,3	60,2
Total in Western Georgia	186,8	100	30,4	16,3	23,3	12,5	9,3	5,0	63,0	33,8
Regions of Eastern Georgia	467,7	100	74,6	15,9	45,0	9,6	9,8	2,1	129,4	27,6
South Ossetian A.Region.	18,7	100	5,5	29,4	6,1	32,6	1,7	9,1	13,3	71,1
Total in Eastern Georgia	486,4	100	80,1	16,5	51,1	10,5	11,5	2,4	142,7	29,4
Total in Georgia	673,2	100	110,5	16,4	74,4	11,0	20,8	3,1	205,7	30,5

Wind erosion is developed in Eastern and Southern Georgia, where the area of arable land susceptible to wind erosion is 102.5 thousand ha, i.e. 21.1% of the total area of arable soils in Eastern Georgia. The modulus of runoff from the river catchment in Western Georgia exceeds the permissible soil erosion limit only in the basins of the Kodori River (at 4,90 t. - 6.60 t/ha), Inguri (at Dizi - 6.30 t/ha), Rioni (near the village of Khidikari - 6.10 t/ha; near the village of Namokhvani - 6.50 t/ha), Kvirila (near the town of Zestafoni - 6.90 t/ha) and Adjaristskali (near the village of Khulo - 6.50 t/ha). The drainage basins of the Chakvistskali rivers (near the village of Khala - 0.92 t/ha), Machakhelistskali (near the village of Sindieti - 0.80 t/ha), in Western Georgia are the minimum washout module; in the catchment basins of the Paravani rivers (near the village of Khertvisi - 0.21 t/ha), Kobliani (near the village of

Mlache - 0.72 t/ha), Tana (near the village of Ateni - 0.37 t/ha), Ksani (at the village of Korinta - 0.76 t/ha), Ktsia-Khrami (at the village of Yedikilisa - 0.52 t/ha, before flowing into the Kura river, at the Red Bridge - 0.30 t/ha), Beyukchay (above the village of Beshtasheni - 0.51 t/ha), Dzhudzhiani (near the village of Trialeti - 0.41 t/ha), Shavtskarstskali (near the village of Kizil-Ajlo - 0.21 t/ha) and Bolnisi (near the village of Samcevrisi - 0.70 t/ha) in Eastern Georgia. The minimum washout modulus in river basins was recorded in the catchment of the river Ktsia-Khrami, in the vicinity the village of Chatakhi is 0.11 t/ha per year. In the remaining river basins of Georgia, the erosion modulus is much lower than the permissible limit, soil erosion rate. In Western Georgia, this is explained by the high percentage of forest land cover in the river basin, which varies from 37 (the basins of the Natanebi and Tekhuri rivers) to 64 percent (the basins of the Supsa and Dzirula).

In Eastern Georgia, the drainage basins of the South Georgia rivers (allocated within the limits of Eastern Georgia) are distinguished by the minimum soil washout modulus, especially the river basins. Dzhudzhiani (0,14 t/ha), Shavtskarstskali and Potskhov (0.21 t/ha). The minimum washout modulus in river basins was recorded in the catchment of the river Ktsiya-Khrami, in the vicinity of the village of Chatakhi - 0.11 t/ha per year. In the remaining river basins of Georgia, the erosion modulus is much lower than the permissible limit, soil erosion rate. In Western Georgia, this is explained by the high percentage of forest land cover in the river basin, which varies from 37 (the basins of the Natanebi and Tekhuri rivers) to 64 percent (the basins of the Supsa and Dzirula).

In Eastern Georgia, the drainage basins of the South Georgia rivers (allocated within the limits of Eastern Georgia) are distinguished by the minimum soil washout modulus, especially within the river basins. of rivers Dzhudzhiani (0,14 t/ha), Shavtskarstskali and Potskhov (0.21 t/ha). As already noted, 17–20% of the total soil particles washed away from arable lands fall into Georgian river waters. Based on this, in the river basins of river Bzyb real flushing of soil with arable land varies from 10 to 23 tons per hectare per year, which in the river basin. Kodori is increasing to 33 t/ha per year. In the upper part of the river basin. Inguri, in Region of Upper Svaneti and in the river basin. of Managa, flushing soil from arable land is 20-31 t/ha per year. In the lower reaches of the river. Inguri, flushing soil from arable land is reduced by 2-3 times and amounts to 11 t/ha per year. Erosion processes on arable lands occur with much lower intensity in the catchment basin of the largest river in Western Georgia - the Rioni, with tributaries of the rivers Tskhenistskali, Kvirila, Dzirula, Tekhuri - where soil erosion varies from 6 to 34 t/ha per year. The maximum content of suspended particles in water of the river of Kvirila is associated with intense erosion of the yields of manganese readily soluble rock layers. In the coastal part of Adjara, as well as in Guria, erosion activity is minimal and varies rom 5 to 13 t/ha per year. In the mountains of Adjara in the lower and middle parts of the river basin of Adjaristskali, the intensity of soil erosion on arable land does not exceed 12 t/ha per year. In the upper part of the basin of the same river, the intensity of soil erosion on arable land increases 2,7 times and amounts to 30-34 t/ha per year.

In the basins of some rivers of the southern slope of the Caucasus Mountain Range, soil loss from arable lands varies from 17 to 31 t/ha per year (the Didi Liakhvi, Aragvi rivers near the village of Chinti, (Village Pasanauri), and in the basins of a number of rivers, soil runoff from arable land is only 4-9 t/ha per year (basins of the Ksani river, Tetri Aragvi). In the catchment basins of the rivers of southern Georgia (the Ktsia-Khrami, Dzhudzhiani, Shavtskarostskali, Bolnisi rivers) the minimum soil wash-off from arable land is observed, which varies from 0.55 to 3.50 t/ha per year. The above level of soil loss during erosion is 1.1 - 7.3 times less than the permissible norm.

In the catchment basins of the rivers of Kakheti - Rivers Iori and Alazani, the flushing of the soil from arable land is 10-21 t/ha per year, which is 2,5-5,0 times higher than the permissible flushing of the soil.

It should be noted that within Georgia, on the arable lands of drainage basins, with the exception of drainage basins of South Georgia, only in drainage basins of several rivers in Western Georgia – River of Machakhelistskali (4.0 t/ha), in Eastern Georgia – River of Kobliani (3.60 t/ha), river of Tana (1.85 t / ha), river of Ksani (3.80 t/ha), soil erosion is less than or equal to the recommended soil erosion during the development of erosion processes.

Table 2. *Display of erosion processes in the main river catchments of Georgia*

River-Point	Catchment area km^2	Discharge		Module of the wash out soil from the catchment area t/ha	Module of the Ionic Discharge t/ha	Total denudation of the basin		Washout of soil from the arable land of catchment basin t/ha
		Weighted sediment thousand t.	Ionic thousand t.			t/ha	mm/year	
Bzib-v. Lower Betega	507	100	103	1.97	2.04	203	0.4	9.85
Bzib- Pitsunda bridge	1510	710	476	4.76	3.15	1186	0.9	23.50
Gumista-Above Sukhumi Hydroelectric Power Station	114	25	19	2.20	1.67	44	0.5	11.0
Kelasuri-v. Bagmarani	214	70	42	3.20	1.96	112	0.6	16.00
Kodori – v. Lata	1420	880	240	6.60	1.69	1120	1.0	33.00
Kodori – v. Varcha	2020	461	341	4.90	1.69	802	0.8	24.50
Enguri - v. Khaishi	2780	1200	486	4.10	1.75	1686	0.7	20.50
Enguri - v. Darcheli	3640	790	699	2.20	1.92	1489	0.5	11.00
Rioni - v. Oni	1060	250	272	2.40	2.57	522	0.6	12.00
Rioni - v. Sakochakidze	13300	5600	2846	4.50	2.14	8446	0.8	22.50
Kvirila - Zestafoni	2490	1700	416	6.90	1.67	2116	1.0	34.5
Dzirula - v. Tseva	1190	200	134	1.70	1.13	334	0.3	8.5
Chkherimela- st. Kharagauli	398	76	56	1.90	1.40	132	0.4	9.50
Tskenistskhali-v. Khidi	1950	510	524	2.60	2.69	1034	0.6	13.00
Tekhuri - v. Nakalaqevi	558	230	184	4.10	3.30	414	0.9	20.50
Sufsa - v. Khidmagala	1100	180	143	1.70	1.30	323	0.4	8.50
Gubazeuli - v. Khidmagala	337	88	29	2.60	0.86	117	0.4	13.00
Natanebi - v. Natanebi	469	80	56	1.70	1.20	64	0.3	8.50
Kintrishi - v. Kohi	191	20	33	1.00	1.75	53	0.3	5.00
Machakhelistskali-v. Sindieti	362	29	20	0.80	0.56	49	0.1	4.00
Ajaristskali - v. Khulo	251	15	30	6.00	1.20	45	0.8	30.00
Ajaristskali - v. Keda	1360	340	178	2.50	1.31	518	0.5	12.50
Paravani - v. Khertvisi	2350	50	92	0.21	0.39	142	0.07	1.05
Potskovi - v. Skhvilisi	1730	280	121	1.60	0.70	401	0.02	8.00
Kobliani - v. Mlashe	468	34	32	0.72	0.69	66	0.1	3.60
Big. Liakhvi - v. Kehvi	924	460	195	4.90	2.11	655	0.8	24.50
Small Liakhvi - v. Vanati	422	74	29	1.80	0.70	103	0.3	9.00
Tana - v. Ateni	283	11	17	0.37	0.62	28	0.1	1.85
Ksani - v. Korinta	461	120	63	0.76	1.36	183	0.2	3.80
White Aragvi - v. Mleta	107	20	36	1.90	3.33	56	0.6	9.50

White Aragvi - v. Pasanauri	335	120	103	6.30	3.07	223	1.1	31.50
Black Aragvi- near the mouth	235	100	57	4.40	2.42	157	0.8	22.00
Pshavis Aragvi-v. Magaroskari	736	260	110	3.50	1.49	370	0.6	17.50
Algeti - v. Partskhisi	359	72	43	2.00	1.21	115	0.4	10.00
Ktsiya-Khrami-v. Edikilisa	544	28	25	0.52	0.46	53	0.1	2.60
Ktsia-Khrami-v. Chatakhi	1420	15	23	0.11	0.16	38	0.01	0.55
Ktsia-Khrami-v. Red bridge	8260	250	917	0.30	1.11	1167	0.01	1.50
Beyukchay-above v.Bestasheni	184	9.4	9	0.51	47	18.4	0.01	2.55
Djujiani-v. Trialeti	126	1.8	6	0.14	0.49	7.8	0.07	0.70
Shavtskarostskali-v. Kizil-Ajlo	328	6.8	15	0.21	0.46	21.8	0.08	1.05
Bolnisi - v. Samtsevrisi	292	21	21	0.70	0.72	42	0.01	3.50
Iori - v. Lelovani	494	100	76	2.00	1.54	176	0.4	10,00
Alazani - v. Chiaura	4530	1900	575	4.10	1.27	2475	0.6	20.50

It is well known that chemical depletion plays an important role in soil formation, which is reflected in the soil profile of certain chemical elements by its movement, interference and accumulation in the lower horizon. Most of the chemicals in the soil and in the depletion zone are flows into the river in the form of lateral runoff. The study revealed that the ionic flow modulus of the river is not known. The Kodori and Enguri basin Module of the Ionic Discharge is up to 2 t / ha. Especially high ionic runoff is the river Tskhenistskali and the river Supsa (Chokhatauri) basin, where ionic runoff reaches 3 t / ha (Fig. 1).

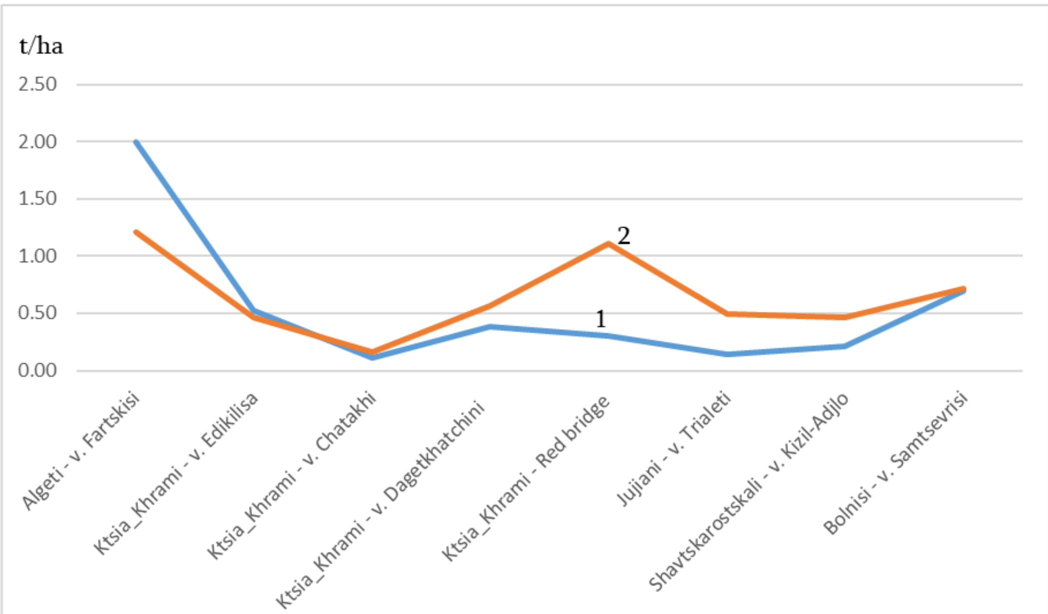

Fig. 1. *Distribution of the annual sediment runoff modulus (1) and ion runoff modulus (2) in the river basins of Western Georgia*

The situation is different in the rivers of southern Georgia. The study found that sediment runoff in all the rivers in the region. The quantity is less than 0,50 t / ha. It is noteworthy that here,

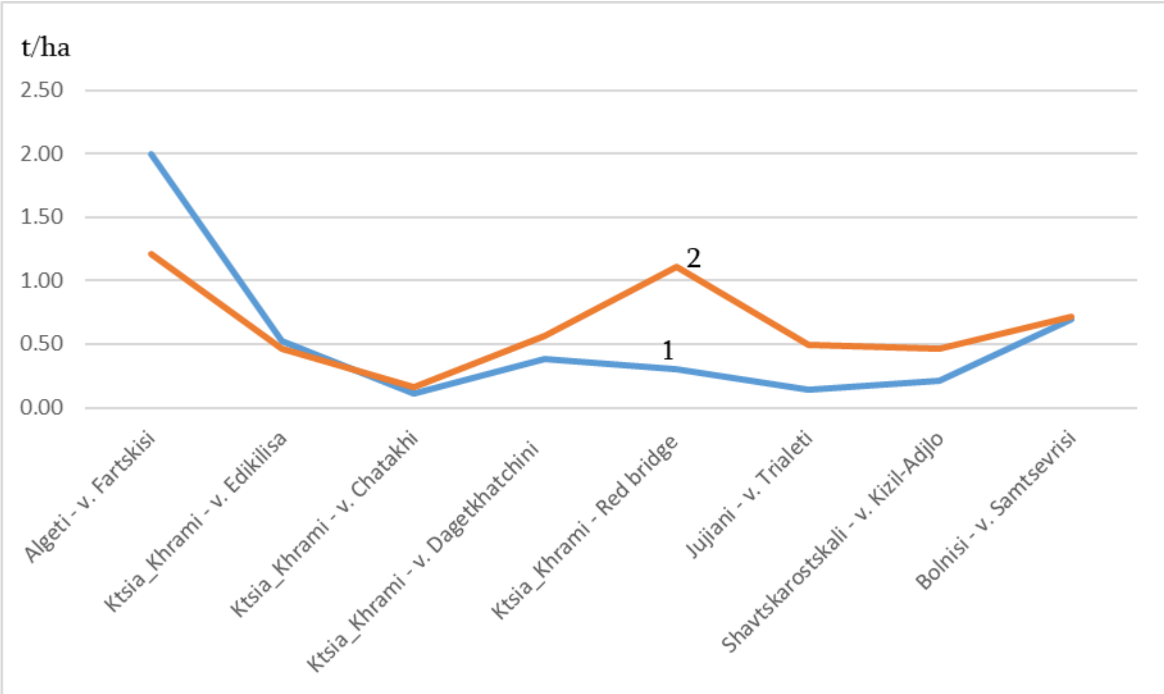

Fig. 2. *The amount of sediment runoff.*

Sedimentary and ionic runoff in both the western and eastern Georgian rivers is much higher than ionic runoff is twice as high in the southern Georgian rivers. Ionian runoff in sediments in southern Georgia exceeds sedimentary runoff, which is not observed in river basins of other regions of Georgia.

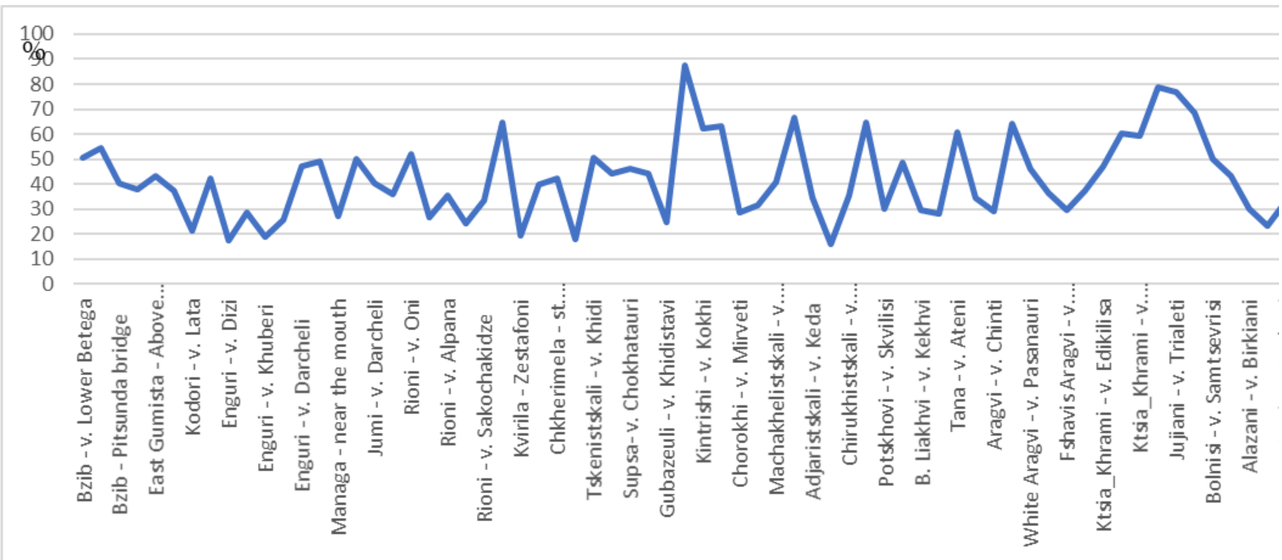

Fig. 3. *Distribution of the annual sediment runoff modulus (1) and ion runoff modulus (2) in the river basins of Eastern Georgia*

The largest ionic runoff from the river basins of Eastern Georgia is distinguished by the river of Aragvi basin, where ionic flow exceeds 3 t/ha (Fig. 3). Here the minimum ionic runoff is observed in the river of Ktsia-Khrami Basin (Vill. Chattakhi).

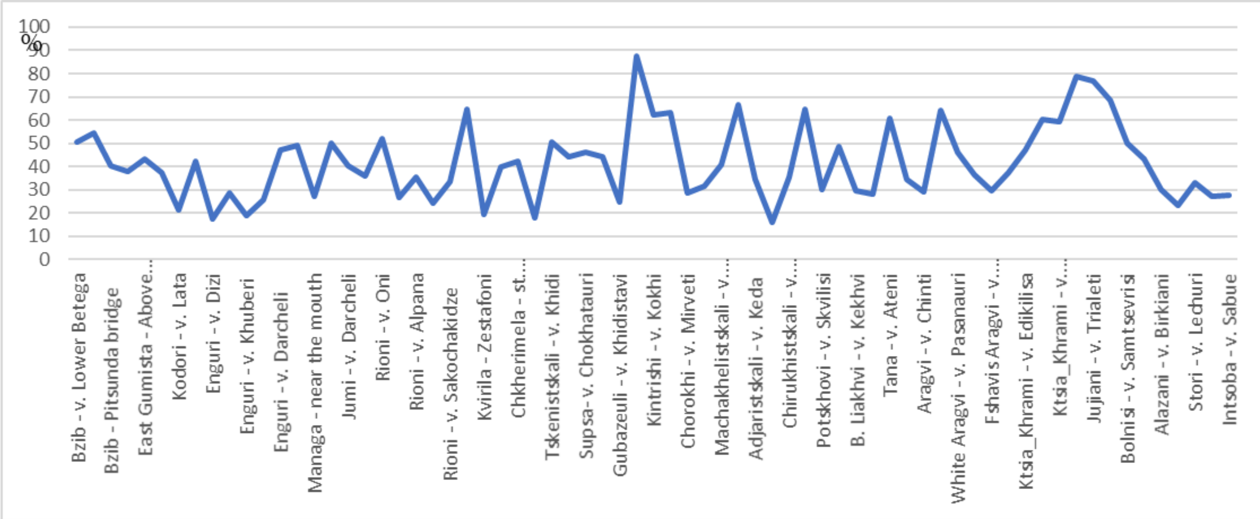

Fig. 4. % Ratio of the module of the ion drain to the modules flushing from the pool

The study found that ionic runoff from the river basins of Georgia varied from 20 to 88% (Fig. 4). It follows that only 50% of the total consolidated runoff from the river basins of Georgia is accounted for during erosion studies. The river Ionic runoff in the Kodori and Enguri basins accounts for 20-50% of the total consolidated runoff from river basin, 20-65% in Rioni river Basin. Ionic runoff in the Guria-Adjara river basins reaches a maximum value - up to 90%. In the Shida Kartli rivers and Aragvi basins the ionic fluxes change up to 30-60%. The ionic runoff ratio is particularly high in the South Georgia rivers, where it reaches up to 80%, however, the solid runoff module is not high in the % of ion runoff - $R^2 = 0.454$, but can be used for spatial distribution of ion runoff in the rivers basin, to determine the regularity (Fig. 5). If we know the number of solid runoff modules, then the logarithmic formula can be used to determine the % content of ion runoff.

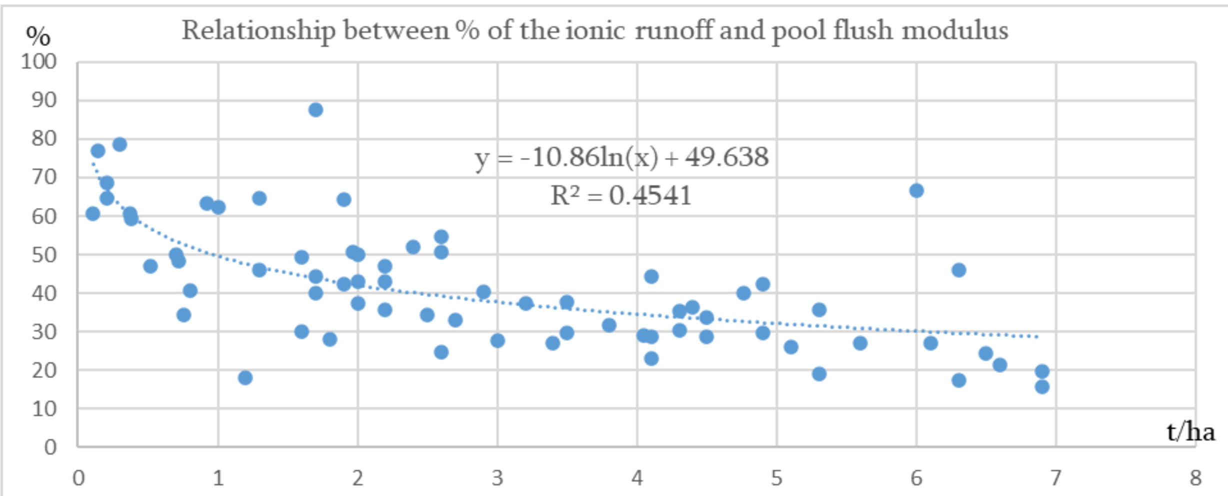

Fig. 5. *Relationship between % of the ionic runoff and pool flush modulus*

Conclusion

The area of the agricultural zone (up to 1800 m above sea level) of Georgia is 51,789.5 km^2, i.e. 74% of the total territory.

The maximum amount of cultivated land in Western Georgia is 28-40%, and in Eastern Georgia 29-33% of the total catchment area of rivers.

Eroded arable land is 205.7 thousand ha, i.e. 30.5% of the total area of arable land, including Weak - 110.5 thousand hectares (16.4%), Average - 74.4 thousand hectares (11.0%) and Heavy eroded lands - 20.8 thousand ha (3.1%).

The average annual flushing with arable land in the catchment areas of Western Georgia is an average of 17.40 t/year, i.e. exceeds the permissible rate of erosion by 4 times. In the river basins of Eastern Georgia - 10.46 t/year per year, which is 2.5 times more than the permissible norm for erosion. Much less than the permissible limit of soil erosion is washed off per year, from arable land in southern Georgia - 3.08 tons per year. It has been found that high ionic flow is observed in the river of Tskhenistskali and the river of Supsa (Chokhatauri) basin, where ionic runoff reaches 3 t/ha.

Ionian runoff in sediments in southern Georgia exceeds sedimentary runoff, which is not observed in river basins of other regions of Georgia.

Ionic runoff from river basins in Georgia varies from 20 to 88 % of the total pool flush modulus.

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