

# Ontogenetic structure of lichen populations as the index of the condition of the urbanized territories

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**Abstract.** The results of population monitoring in lichen indication promote the detection of resistance of lichen species to the pollution of environment. The population of *Xanthoria parietina* (L.) Th. Fr. on the territory of the city of Samara and in the neighborhood of the Bolshaya Glushitsa settlement (Bolsheglushitsky district, Samara region) (Russia) were studied. For identification of ontogenetic conditions of talluses, the approaches and a nomenclature of population and ontogenetic researches of Magnoliophyta were used. Taking into account the exposition, the projective cover of *Ulmus pumila* trunks with *Xanthoria parietina* talluses was revealed. On *Ulmus pumila* tree stems in the Bolshechernigovsky municipal district of Samara region the prevailing ontogenetic group in populations of *Xanthoria parietina* is young generative group, within the city it is mature generative group. Talluses in the same course of ontogenetic development have the least area, and then, the vitality, on the western part of a trunk, and the greatest on the south side. At the same time the vital level of tallus directly depends on the level of environmental pollution. The decrease in the number of talluses is related to indexes of density, illumination, natural tree mortality, cuttings, fires, diseases of tree species.

## 1 Introduction

Nowadays the aspects of studying lichens at the population level of their organization are considered by the Russian scientists (Suyetina, 1999, 2001, 2006, etc.). Population of lichens is usually understood to be a local group of talluses of the same species which is more or less separated from other same groups over a distance.

However small groups and even a single tallus of a lichen, according to lichen scientists, are not always independent individuals, but they are formed of several rudiments which adjoin, coalesce and form one tallus. Within this context a single tallus is considered as a sampling unit.

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Population monitoring as a section of lichen indication gives more reliable results promoting the detection of species' resistance to environmental pollution, than standard techniques do.

While studying populations of lichens, it is almost impossible to determine calendar age of individuals, therefore biological age with naming ontogenetic states is used.

The ontogenetic profiles of populations studied in the nature will be conditionally uncompleted because the microscopic individuals being at the early stages of ontogenesis aren't fixed.

We have studied such lichen population as *Xanthoria parietina* (L.) Th. Fr. spread on the territory of the city of Samara and in the outskirts of the Bolshaya Glushitsa settlement (Bolsheglushitsky area, Samara region) (Russia) which supplies population ontogenetically oriented works in our region (Il'ina, 2018, 2019).

Studying the populations of lichens is a rare kind of research despite its relevance so far.

## 2 Object and technique of research

*Xanthoria parietina* is the most routine lichen across this territory; it is extended on a crust of broadleaved species. It is also often seen on the processed wood, fences, roofs and walls of constructions. Its tallus is well noticeable from a distance and looks like almost regular shaped yellow-orange rosette, which center is nearly always entirely covered with close-set, usually more bright apothecium. Tallus is foliaceous and lamina, rosette; it is from 1 to 20 cm in diameter and connivent to substrate. A colour of the upper side of a tallus varies from yellowish-green to bright orange, it is pale shiny, smooth or a little bit wrinkled, the underside is white, slightly yellowish at the edges, with fuscous rhizoids. Tallus blades are either quite wide and large, or shallow and narrow, and sinuate-bladed on the ends. Nitrophilous polymorphous species are widespread. They are very common and riotous on the unshaded trunks of trees, along the roads, near dwellings. Its area includes Europe, Asia, Africa, America, Australia.

In order to identify ontogenetic status of lichen species the same approaches and terminology as for vascular plants can be used. On each territory we studied about 10 trees. At the height about 1.5 meters above ground level spots of lichen populations were mapped. Further the projective tallus cover of tree trunks was fixed taking into account an exposition (the North, the East, the South, the West). Ontogenetic statuses of individuals are revealed basing on the shape.

Traditional methods of lichen indication of the environment (Skye, 1968; James, 1982; Martin, 1984; Byazrov, 2002; Baybakov, 2003; Scheidegger, Werth, 2009) and the population and ontogenetic research techniques of organisms which have already become traditional (Gauslaa, 1997; Mikhaylova, Vorobeychik, 1999; Suyetina, 1999, 2001, 2006, 2012; Mikhaylova, 2004; Fedrowitz, Kuusinen, Snäll, 2012; etc.) were used during our study.

However, a clear definition of what a lichen population is currently does not exist. Usually, this term refers to a local group of thalli of one species, more or less spatially separated from other similar groups. Ontogenesis of lichens can be divided into four phases: the resettlement of diaspores, germination, growth of tallus and the production of diaspores. In nature, it is possible to observe only the stages at which the tallus already quite large. In the description of ontogenesis (in nature), differentiation at the stage is used (immature - im, virgin - v, young generative - g1v, mature generative - g2v, old generative - g3v, sub-senile - ss). Nowadays adult individuals are called potentially generative (young generative group - g1v, mature generative group - g2v, old generative group - g3v).

The ratio of ontogenetic groups of individuals (talluses) represents the ontogenetic spectrum of the population. The type of ontogenetic spectrum of the population and its changes under any influence serve as a parameter for monitoring the state of the environment.

### 3 The research results

#### 3.1 Projective lichen cover of trunks

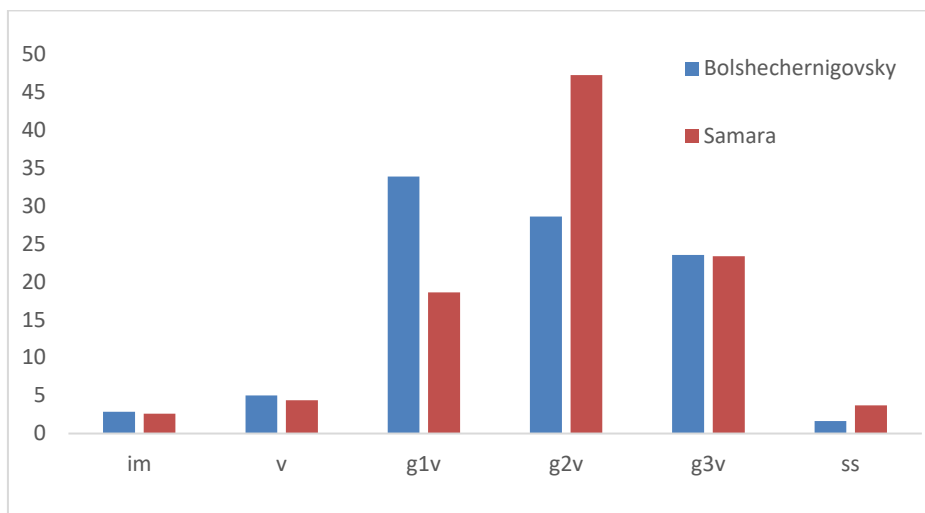
Taking into account an exposition the projective cover of *Ulmus pumila* trunks by *Xanthoria parietina* talluses is revealed. It turned out that in the Bolshechernigovskiy municipal district of Samara region, where an average height of trees is about 3.82 meters and tree girth is 70.26 centimeters, the projective cover of a crust by lichens is 21.18% in the north side, 18.88% in the west, 19.46% in the south, 18.38% in the east. In general trunks are covered with lichens by 19.36%.

Across the territory of the city of Samara where an average height of trees is about 3.40 meters and tree girth is 64.13 centimeters the projective cover of tree crust by lichens is 16.43% in the north side, 13.21% in the west, 13.18% in the south, 11.56% in the east. In general trunks are covered with lichens by 13.60%.

However, all these indexes depend on a condition of a forest stand which is under the influence of various anthropogenic factors. However the projective cover of *Xanthoria parietina* is significantly lower in the urbanized environment.

#### 3.2 Ontogenetic structure of *Xanthoria parietina* populations

It is established that in the Bolshechernigovskiy municipal district of Samara region the prevailing ontogenetic group of *Xanthoria parietina* populations on trunks of *Ulmus pumila* is young generative group (g1v) which has about 34% of individuals; mature generative group (g2v – about 29%) and old generative group (g3v – about 24%) are placed second and third in number of talluses respectively. Other stages are presented in a very slight degree (fig. 1). It is due to the length of growth and existence of adult talluses and also absence of calculation of microscopic individuals.



**Fig. 1.** Basic ontogenetic range of populations of *Xanthoria parietina* in Bolshechernigovskiy district of Samara region and in the Samara city (the number of individuals is given in percent (%))

In the urban environment the prevailing ontogenetic group in *Xanthoria parietina* populations on trunks of *Ulmus pumila* is mature generative group (g2v), which has about 47% of individuals, aged generative group (g3v – about 23%) and young generative group

(g1v – about 18%) are placed second and third in number of talluses respectively. Other stages are presented by fewer individuals (fig. 1). The ratio of groups of individuals across the studied areas differs. However there is no exact dependence on an exposition (cardinal direction). Probably, the indicator of illuminating intensity diminishes by shadowing from neighbouring trees. However with the increase in emission status of environment the percent of young generative individuals is noteworthy falling nearly by half, and mature generative individuals, on the contrary, are increasing the number of population.

### 3.3 Vital condition of populations

The calculated ratio of a projective tallus cover of tree trunks to the quantity of talluses depending on an exposition, shows that talluses on the western part of a trunk with the same stage of development have the least area, in compliance with vitality, and on the south side it is the greatest.

The index of vitality demonstrates the increase in vital level among stationary areas that also coincides with the increase in air pollution and the increase of an anthropogenic pressure.

### 3.4 Number of populations

When the number of lichen talluses on a tree increases and reaches an exact point, this fact can be linked with overrunning the particular indexes of the density of tallus per unit area. However any vivid regularity wasn't revealed though there is affiliation with illuminating intensity of a tree trunk surface.

The attendance of natural populations of *Xanthoria parietina* revealed that the reduction of number of talluses firstly connected with the fact that the trees, which the lichens grow on, drop out of phytocenosis because of the process of ageing and cutting. A great influence on the number of populations is created by injuries of bark caused by wildfires, formation of cracks in frosty winters, diseases of trees (injuries caused by *Erysiphales*, decay and others).

### 3.5 Influence of the fires on *Xanthoria parietina* populations

Annually Samara region belongs to the regions of Russia with a high level of a forest fire danger. Lichens are very sensitive to the fires as they grow on a surface of trunks and burn out quickly. But at the same time they are the pioneer species capable to develop on burned areas.

The first stage of our investigation showed the average growth of 657 talluses on discount areas (on one tree), the structure of their ontogenetic groups was the following: im – 2.4%, v – 14.4%, g1v – 28.6%, g2v – 27.3%, g3v – 23.4%, ss – 2.7% (fig. 2).

As a result of the fire their number cut to 213 of individuals, the burning reflected badly on their conditions; the ratio of ontogenetic groups was the following: g2v – 68.5%, g3v – 31.5%. Other groups weren't noted.

During the first year after the fire there was an insignificant increase in total number of individuals up to 220, however young talluses got only about 3% of the total number, some taluses damaged by fire died. Ontogenetic range of population was the following: im – 1.5%, v – 1.5%, g1v – 6.0%, g2v – 57.5%, g3v – 43.5%, ss – 0%.

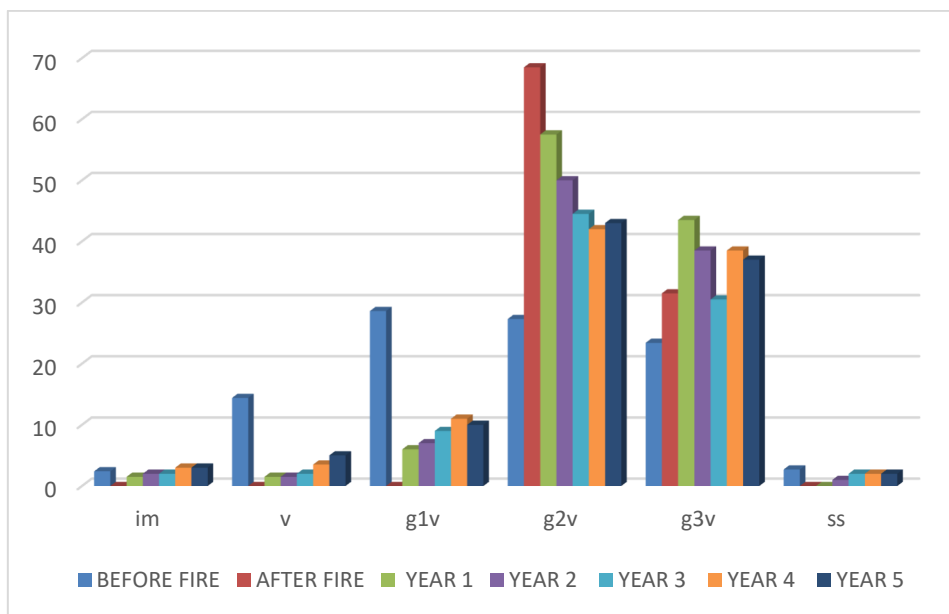
During the second year after the fire there was an increase in number of talluses up to 250. Ontogenetic range of population was the following: im – 2.0%, v – 1.5%, g1v – 7.0%, g2v – 50.0%, g3v – 38.5%, ss – 1.0%.

During the third year after the fire the number of talluses on the discount areas increased up to 288 of them: im – 2.0%, v – 2.0%, g1v – 9.0%, g2v – 44.5%, g3v – 30.5%, ss – 2.0%.

During the fourth year of observations 350 talluses were noted after the fire. The ontogenetic range showed further increase in a share of young talluses: im – 3.0%, v – 3.5%, g1v – 11.0%, g2v – 42.0%, g3v – 38.5%, ss – 2.0%.

During the fifth year after the fire the number of talluses on the discount areas came to 380 individuals. The ontogenetic range has practically the same values, as during the previous year: im – 3.0%, v – 5.0%, g1v – 10.0%, g2v – 43.0%, g3v – 37.0%, ss – 2.0%.

The researches show the low rate of increase in number of talluses and gradual "leveling-off" of populations according to the structure of ontogenetic groups.



**Fig. 2.** The dynamics of ontogenetic structure of *Xanthoria parietina* populations after the fire (the number of individuals is given in percent (%)).

## 4 Conclusions

The lichens accumulating toxicants in the tallus are very informative bioindicators of the condition of the air environment. The slightest air pollution which doesn't affect the majority of plants causes mass mortality of many species of lichens, including *Xanthoria parietina*. The ability of lichens to react to air pollutions is on the basis of a lichen indication.

Nowadays the issues of population structure of lichen species are extensively discussed by native scientists. Using population approach in studying lichens gives the chance to get objective information about the resistance of types to environmental pollution.

*Xanthoria parietina* is spread in habitats which are badly anthropogenically changed. *Xanthoria parietina* as test organism of the state of environment condition comprises the following most important indicators: projective cover of substrate with talluses and vitality of population. The ontogenetic structure of populations can be only an additional method in case of a complex assessment of a habitat.

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