Characteristics of lighting parameters and its interception by the crowns of *Cotoneaster lucidus* Schlecht. bushes in forest parks of Yekaterinburg

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Abstract. *Cotoneaster lucidus* Schlecht. distributed in twelve of fifteen forest parks in Yekaterinburg on an area of 396.8 hectares. The lighting parameters in different parts of the crown of pregenerative individuals of cotoneaster in the Karasye-Ozersky and Malo-Istoksky forest parks, as well as the ability to intercept light, were studied. The percentage of light interception by the entire crown is 41% and 51% for cotoneaster habitats, respectively. The average heights (H) and the minimum and maximum diameters of bush crowns (Dmin, Dmax) in the two habitats do not differ significantly. The parameters of illumination and its interception by different parts of the crown have their own characteristics for the two samples. There are no correlations between the measured heights and crown diameters of bushes and the considered lighting parameters. The initial illumination above the crowns of the bushes for the habitat in the Malo-Istoksky forest park has low values compared to the Karasye-Ozersky forest park, apparently this is a consequence of shading of the bushes. Differences in incoming illumination caused differences in the structure of correlations between the parameters of its interception. For the habitat in the Malo-Istoksky Forest Park, all correlations are high positive, while in the Karasye-Ozersky Forest Park some correlations are absent, and some are negative correlations. Other features of interception of illumination by the crowns of cotoneaster bushes were noted.

1 Introduction

Alien invasive plants in some cases are capable of exhibiting the properties of strong edificators [1]. Many researchers argue that alien plants create a denser leaf canopy than native plants [2-5]. The manifestations of cotoneaster brilliant in relation to the shading effect on native flora in the secondary habitat in forest parks of Yekaterinburg have been

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little studied. The purpose of the study is to assess the interception of the light regime in different parts of the crown of Cotoneaster.

2 Materials and methods

According to the botanical and geographical zoning of the Sverdlovsk region, the city of Yekaterinburg is located in the southern taiga boreal forest subzone [6], it is surrounded by forest parks and urban forests. A study of pregenerative cotoneaster individuals was carried out in 2022 in four habitat fragments (HF) in Karasye-Ozersky and in four habitat fragments in the Malo-Istoksky forest park of Yekaterinburg. Standard methods were used to characterize habitats [7-8]. Illumination was assessed using a digital multifunctional environmental parameter meter MS-6300. Illumination indicators were measured: above the crown, in the middle of the height of the cotoneaster and at the base of the stems.

The average values and standard errors of the initial lighting parameters in different parts of the crown and the same parameters after logarithm were calculated. Other statistics were calculated for logarithmic parameters. A correlation analysis was carried out involving the parameters of lighting and light interception at different levels of the crowns of *Cotoneaster lucidus* bushes, as well as the heights and diameters of the crowns. The two habitats were compared using the non-parametric Mann-Whitney test to determine differences in light parameters between the respective samples of shrubs. The distributions of logarithmized light parameters and light interception values were identified in two habitats. The average heights (H) and minimum and maximum crown diameters (D_{min}, D_{max}) in the two habitats did not differ significantly and were, for the habitat in the Malo-Istoksky Forest Park: 1.36 ± 0.06 m, 0.97 ± 0.075 m, 1.22 ± 0.08 m; for the habitat in the Karasye-Ozersky forest park: 1.48 ± 0.07 m, 1.00 ± 0.08 m and 1.27 ± 0.09 m, respectively.

3 Results

Cotoneaster lucidus Schlecht. - one of the oldest plants that originated in Southeast Asia, with many primitive characteristics. Its introduction range extends throughout Eurasia and Europe. Cotoneaster has actively invaded all forest parks in Yekaterinburg. Its spread was facilitated by the presence of edible, long-lasting fruits on the shoots, which provided food for many species of birds [9]. In the forest parks under study, the number of cotoneaster individuals ranges from 365 to 678 individuals per hectare with a tree canopy density of 0.3-0.5 (Table 1).

Table 1. Characteristics of *Cotoneaster lucidus* habitats in forest parks of Yekaterinburg.

Habitat				
Habitat fragment number	**tree stand**			**Total density, ind./ha**
	forest type	**compound**	**tree canopy density**	
Malo-Istok Forest Park				
1	Pine forest of various herbs	8C2B	0.4	622
2	Pine forest of various herbs	10C	0.5	678
3	Pine forest of various herbs	8C2B	0.4	500
4	Pine forest of various herbs	10C	0.3	367
$X \pm mx$			0.4	542
Karasye-Ozersky Forest Park				
5	Berry pine forest	7C3B	0.4	612
6	Pine forest of various herbs	10C	0.5	654
7	Pine forest of various herbs	8C2B	0.4	502
8	Pine forest of various herbs	10C	0.3	365
$X \pm mx$			0.4	533

When studying the interception of light, the following average parameters of illumination L, interception of illumination by sections of the crown of bushes Δ L *Cotoneaster lucidus* were obtained (designations L: above - above the crown, inside - in the middle of the crown, below - under the crown) (Table 2).

Table 2. Average parameters of illumination and interception of illumination in different parts of the crown of *Cotoneaster lucidus*.

Initial parameters (M±SE)					
Lighting	**Malo-Istok**	**Karasye-Ozersky**	**Interception of lighting**	**Malo-Istok**	**Karasye-Ozersky**
L_{above}, lk	637.3±41.8	2035.7±39.3	$L_{above} - L_{inside}$, lk	171.8±16.6	458.4±31.5
L_{inside}, lk	465.5±31.6	1577.2±35.9	$L_{above} - L_{below}$, lk	326.6±27	835.8±38.3
L_{below}, lk	310.7±20.5	1199.8±35.3	$L_{inside} - L_{below}$, lk	154.7±17.5	377.4±22.1
Logarithmic parameters (M±SE)					
Ln (L_{above})	6.21±0.074	7.59±0.019	Ln ($L_{above} - L_{inside}$)	4.67±0.104	5.88±0.071
Ln (L_{inside})	5.91±0.07	7.33±0.023	Ln ($L_{above} - L_{below}$)	5.41±0.093	6.62±0.044
Ln (L_{below})	5.52±0.067	7.03±0.033	Ln ($L_{inside} - L_{below}$)	4.56±0.103	5.67±0.092

Table 3 below shows the relative interception of radiation to illumination above the crown (the last line is the relative interception of illumination by the entire crown).

Table 3. Relative values of light interception in different parts of the crown of *Cotoneaster lucidus*.

Light interception rate	**Crown part**	**Light interception percentage, %**	
		Malo-Istok	**Karasye-Ozersky**
(L_{above}–L_{inside})/ L_{above}*100%	Top part	26.96	22.52
(L_{inside}–L_{below})/ L_{above}*100%	Bottom part	24.29	18.54
(L_{above}–L_{below})/ L_{above}*100%	Whole crown	51.24	41.06

Thus, the interception of light in the crown of *Cotoneaster lucidus* for the two habitats is 51% and 41%, respectively.

Correlations between logarithmized parameters of illumination and interception of illumination for habitats located in the Malo-Istoksky and Karasye-Ozersky forest parks are shown in Table 4.

Table 4. Correlations between light and light interception parameters in different parts of the crown of *Cotoneaster lucidus* for two habitats (significant correlations at the $p < 0.05$ level are shown in bold).

Lighting options	**L_{above}**	**L_{inside}**	**L_{below}**	**L_{above}–L_{inside}**	**L_{above}–L_{below}**	**L_{inside}–L_{below}**
	Habitat in Malo-Istok Forest Park					
L_{above}	1.00	**0.964***	**0.879***	**0.851***	**0.950***	**0.800***
L_{inside}		1.00	**0.929***	**0.692***	**0.867***	**0.826***
L_{below}			1.00	**0.615***	**0.703***	**0.587***
L_{above}–L_{inside}				1.00	**0.900***	**0.564***
L_{above}–L_{below}					1.00	**0.848***
L_{inside}–L_{below}						1.00
	Habitat in Karasye-Ozersky forest park					
L_{above}	1.00	**0.642***	**0.440***	**0.474***	**0.545***	0.182
L_{inside}		1.00	**0.742***	**-0.275***	-0.072	**0.255***
L_{below}			1.00	-0.192	**-0.432***	**-0.228***
L_{above}–L_{inside}				1.00	**0.701***	-0.096
L_{above}–L_{below}					1.00	**0.450***
L_{inside}–L_{below}						1.00

There are no correlations between the measured heights and crown diameters of bushes and the considered lighting parameters. It is necessary to note a significant feature of lighting for habitats in the Malo-Istoksky Forest Park - low lighting values above the crowns of bushes, significantly lower than for habitats in Karasye-Ozersky, apparently this is a consequence of shading of bushes. With such low illumination in this habitat, there is a positive correlation between almost all parameters of illumination and light interception. In this case, we can note relatively low correlation coefficients for intercepting illumination with the upper half of the crown ($L_{above}–L_{inside}$) and illumination inside (L_{inside}) and under the crown (L_{below}), as well as for intercepting illumination with the lower half of the crown ($L_{inside}–L_{below}$) and illumination under the crown (L_{below}) and interception of the upper half of the crown ($L_{above}–L_{inside}$). In the case of habitats in the Karasye-Ozersky Forest Park, on the contrary, the illumination above the crowns of the bushes is very high. In this case, two features can be noted: a negative correlation between the interception of illumination by the upper half of the crown ($L_{above}–L_{inside}$) and the illumination inside the crown (L_{inside}), and between the illumination under the crown (L_{below}) and the interception of illumination by the lower half of the crown ($L_{inside}–L_{below}$) and the entire crown ($L_{above}–L_{below}$); lack of correlation between the interception of illumination by the upper half of the crown ($L_{above}–L_{inside}$) and the illumination at the bottom of the crown (L_{below}), between the interception of illumination by the entire crown ($L_{above}–L_{below}$) and illumination inside the crown (Linside), between the interception of illumination by the lower half of the crown ($L_{inside}–L_{below}$) and lighting above the crown (L_{above}) and interception of the upper half of the crown ($L_{above}–L_{inside}$).

The following are the results of a comparison of two habitats based on tree crown parameters and logarithmized light parameters; the nonparametric Mann-Whitney test was used (Table 5).

Table 5. Comparison results for *Cotoneaster lucidus* habitats based on crown and lighting parameters (significant differences at the $p < 0.05$ level are highlighted in bold).

Parameter	Rank Sum Malo-Istok	Rank Sum Karasye-Ozersky	U-statistics	Z-statistics	p-value
H, m	13946.5	14973.5	6686.5	-0.95	0.340
D_{min}, m	14410	14510	7150	-0.092	0.927
D_{max}, m	14346	14574	7086	-0.211	0.833
L_{above}, lk	5068.5	15637.5	118.5	**-12.02**	**<0.00001***
L_{inside}, lk	5123	15583	173	**-11.89**	**<0.00001***
L_{below}, lk	5145	15561	195	**-11.84**	**<0.00001***
$L_{above}–L_{inside}$, lk	6723	13983	1773	**-8.07**	**<0.00001***
$L_{above}–L_{below}$, lk	6132	14574	1182	**-9.48**	**<0.00001***
$L_{inside}–L_{below}$, lk	6615	14090.5	1665.5	**-8.32**	**<0.00001***

As can be seen from Table 5, the habitats do not differ in the size parameters of the crowns of the bushes, while they differ significantly in all parameters of light intensity and light interception by the crowns.

The differences in the distributions for the parameters (logarithmized) of light intensity and the interception of light by the entire crowns between two habitats (Malo-Istoksky - 1, Karasye-Ozersky - 2 forest parks) are illustrated in Figure 1 below. Illumination above the crowns of bushes (Figure 1, a) is significantly lower and has a much wider range of variation for the Malo-Istoksky forest park, and for Karasye-Ozersky it is concentrated in a narrow interval, therefore, the distribution of light interception by entire crowns (Figure 1, b) have the appropriate form.

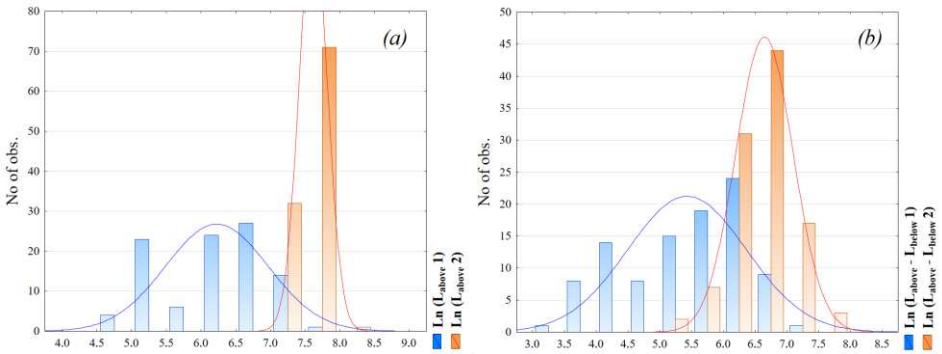

Fig. 1. Graphs of differences in distributions for logarithmized illumination parameters (a – illumination above the crowns; b – interception of illumination by the entire crowns: Malo-Istoksky forest park – 1, Karasye-Ozersky forest park – 2).

4 Discussion

The habitats of *Cotoneaster lucidus* do not differ in the dimensional parameters of the crowns of the bushes - heights and diameters, however, the intensity of illumination above the crowns differs significantly (3 times for the initial data). Apparently, this fact leaves a significant imprint on the nature of the interception of lighting by crowns. It can be concluded that differences in the interception of light by crowns in habitats are not due to the characteristics of the crowns, but to differences in incoming light. The interception of illumination by the crown as a percentage of the illumination above the crown is equal to 51.24% and 41.06%, respectively, for habitats in the Malo-Istoksky and Karasye-Ozersky forest parks. All parameters of illumination and its interception by the crowns of bushes are significantly different in the two habitats, and the nature of the correlation of these characteristics is also significantly different.

Differences in incoming light caused differences in the structure of correlations between the parameters of its interception by the crowns of bushes. For the habitat in the Malo-Istoksky Forest Park, all correlations are high positive, while in the Karasye-Ozersky Forest Park some correlations are absent, and some are negative correlations. What is common in both cases are the reduced correlations for interception of illumination by the upper half of the crown (L_{above}–L_{inside}) and illumination inside (L_{inside}) and under the crown (L_{below}), and for interception of illumination by the lower half of the crown (L_{inside}–L_{below}) and illumination at the bottom of the crown (L_{below}). and interception of the upper half of the crown (L_{above}–L_{inside}). There are no correlations between the dimensional parameters of bush crowns (H, D_{min}, D_{max}) and lighting parameters.

5 Conclusion

In conclusion, based on the results of the analysis of data on lighting in different parts of the crown of *Cotoneaster lucidus*, it can be concluded that, apparently, the difference between the two habitats is caused not by the parameters of the bush crowns and their interception of light, but by a significant difference in the initially incoming lighting above the crowns in the two studied habitats . Within one habitat, light interception parameters are correlated, but in a significantly different way from another habitat. At the same time, the macroparameters of crowns—their heights and diameters—do not correlate with light interception parameters. Thus, the ability of cotoneaster to influence plant communities is

due to a strong decrease in the intensity of the light regime available to other plants under the canopy of its bushes due to shading by the crown.

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