AgroLife Scientific Journal - Volume 9, Number 1, 2020
ISSN 2285-5718; ISSN CD-ROM 2285-5726; ISSN ONLINE 2286-0126; ISSN-L 2285-5718

GROWTH SIGNS OF *Nymphaea candida* IN VARIOUS ECOLOGICAL AND CENOTIC CONDITIONS OF DESNA BASIN (UKRAINE)

Iurii SKLIAR, Viktoriia SKLIAR, Anna KLYMENKO, Maryna SHERSTIUK, Inna ZUBTSOVA

Sumy National Agrarian University, 160 Herasym Kondratiev, Sumy, 40021, Ukraine, Phone/Fax: +380542701055

Corresponding author email: sul_bio@ukr.net

Abstract

Nymphaea candida J. et C. Presl. is a relict species which is a typical representative of an ecological group of attached aquatic higher plants with floating leaves. The conducted research was meant to evaluate the indicators that characterize the Nymphaea candida growth in different conditions of the Desna River basin and to find out the influence of the leading ecological-cenotic factors on them. Based on the analysis of 12 dynamic metric morphological parameters values and five dynamic allometric values, the information on Nymphaea candida plant growth rate in six communities is provided. The influence on the growth of such environmental factors such as the phytocoenoses Total plant cover, water column, its transparency andnature of bottom sediments was evaluated. The water colum and phytocoenoses overall projective coverage showed statistically significant effects, with a force of 54.4-99.0% and 23.6-90.0%, respectively, on all dynamic morphoparameters of Nymphaea candida plants. The bottom sediments did not show a statistically significant effect on only one morphoparameter, and the factor influence force on the dimensional features of Nymphaea candida plants mainly varies within 8.7-89.5%. Water transparency did not show a statistically significant effect on the three morphological parameters, given the influence of this factor on all other features at the level of 13.2-19.4%. In Nymphaea candida plants, the largest majestic significant proportion (58.8%) of the dynamic morphoparameters were in the population of Nymphaea candida - Potamogeton lucens community, the smallest (in 64.7%) were in Numphoides peltata - Ceratophyllum demersum. The fastest growth of Nymphaea candida plants is in areas where there is no flow, the water columnvaries within 50-100 cm, the water transparency reaches the bottom, the silt bottom sediments are represented, and the phytocoenoses total projective coverage is 60-85%. Nevertheless, the total plant cover of Nymphaea candida can be from 10% to 40%. Within the study area, such habitat conditions are optimal to ensure the continued existence of populations of this species as a whole.

Key words*: population, growth, dynamic morfoparametry, environmental coenotic factors, Nymphaea candida.*

INTRODUCTION

Nymphaea candida J. et C. Presl. is a typical representative of an ecological group of attached aquatic higher plants with floating leaves (Heidan, 1965; Dubyna, 1975; 2006; Dubyna et al., 1993). In the study region, this species grows in river beds, bays, floodplains, reservoirs. In the composition of aquatic phytocenoses, it is quite often the dominant or co-dominant (Dubyna, 1982). However, due to the steadily increasing negative anthropogenic impact on aquatic ecosystems, *Nymphaea candida* is becoming less common. In some regions of Ukraine, in particular in the Sumy region, it is already included in the list of species in need of special protection (http://knt.sm.gov.ua/).

Considering that *Nymphaea candida* is a relict, and phytocoenoses with the participation of this species successfully perform ecologically-stabilizing functions (water treatment, energy storage, conservation and biogeochemical), the topical issue is its conservation at the population level (Dubyna, 1982; Zlobin, 1992). However, at present, the population level of *Nymphaea candida* has not been sufficiently studied. An important component of the development of a set of approaches based on science concerning the organization of *Nymphaea candida* populations' active protection is the study of features and patterns of growth of individuals in different ecological-cenotic conditions.

In general, growth is an integral phenomenon that reflects the level and ratio of all physiological and biochemical processes that occur in plants. Besides, growth is the best indicator of the individuals' vitality level (Zlobin et al., 2009). It is not by chance that

scientists pay considerable attention to the estimation of growth processes in plants. However, meantime, such studies have largely covered terrestrial plants (Morozova, 2009; Scherbakova & Novosad, 2013; Skliar & Zlobin, 2013; Klymenko & Skliar, 2015) and aquatic plants have been covered very little. There are some papers dedicated to the estimation of growth parameters in *Trapa natans* L. sl (Skliar & Skliar, 2017) and *Potamogeton natans* L. (Skliar, 2017).

The research was aimed to evaluate the indicators characterizing the growth of *Nymphaea candida* in different conditions of Desna basin and to find out the influence of the leading ecological-cenotic factors on them.

MATERIALS AND METHODS

The basis of the presented publication is grounded on the results of researches carried out in the reservoirs of Desna basin in six communities of higher aquatic plants, which differ significantly from each other in the complex of ecological-cenotic features (Table 1). There were studied as typical (No. 3, 5, 6) so as less common communities in the region (No. 1, 2, 4). The set of selected sites forms a complex ecological-cenotic gradient where the water column, its transparency, the bottom sediments, the total plant cover of the community, etc. are changing.

Table 1. Ecological-coenotic characteristics of habitats of *Nymphaea candida* coenopopulations

№ Of the water reservoir (habitat)	Community	Average water column, cm	Flow	Water transparency, cm	Bottom sediments	Total plant cover, %
1	*Nymphoides peltata - Ceratophyllum demersum*	40	absent	To the bottom	sandy silt	100
2	*Nymphaea candida purum*	60	absent	To the bottom	silty	60
3	*Nuphar lutea - Ceratophyllum demersum*	90	absent	To the bottom	silty	85
4	*Nymphaea candida - Potamogeton lucens*	100	absent	To the bottom	silty	85
5	*Nuphar lutea purum*	120	absent	90	silty	80
6	*Nuphar lutea + Potamogeton natans*	140	absent	75	silty	70

According to conventional approaches (Hejny, 1960; Belavskaya, 1982; Dubyna, 1982; Skiar, 2006), in each community, there were made geobotanical descriptions, which were accompanied by an assessment of the species composition of the phytocenosis, their abundance and projective coverage, as well as water column, water flow, water transparency and nature of bottom sediments.

To estimate the growth rates of *Nymphaea candida*, 20-25 plants of this species in each population were studied, in which the complex of size indicators such as total phytomass (W), leaf phytomass (WL), leaf number (NL), leaf area (A), length of the petiole (H), mass (Wg) and number (Ng) of generative organs were evaluated. As predicted by the method of estimation of growth indicators, the account of these characteristics was performed twice during the period of intensive plant growth with an interval between measurements of 10-14 days.

Based on these calculations, we determined the values of dynamic morphological parameters, which, in turn, according to conventional approaches (Hunt, 1978; Zlobin, 1989; Zlobin et al., 2009), were divided into two groups:

a) metric group which provides information on the change rate of the size of a single metric indicator in ontogeny (Table 2);

b) allometric group which reflects the change rate of allometric ratios in ontogeny (Table 3).

Table 2. List of dynamic metric morphological parameters that were used to estimate *Nymphaea candida* plant growth

Morphoparameters	Symbols and formulas of morphoparameters[1]	Units of measurement
Absolute growth rate indicators		
Absolute growth rate of total phytomass	$AGR = (W_2 - W_1) / \Delta T$	g/day
Absolute growth rate of the total mass of leaves	$AGRWL = (WL_2 - WL_1) / \Delta T$	g/day
Absolute speed of leaf area formation	$AGRA = (A_2 - A_1) / \Delta T$	cm^2/day
Absolute growth rate of length	$AGRH = (H_2 - H_1) / \Delta T$	cm/day
Absolute speed of leaf formation	$AGRNL = (NL_2 - NL_1) / \Delta T$	pcs./day
Absolute growth rate of generative organs mass	$AGRWg = (Wg_2 - Wg_1) / \Delta T$	g/day
Absolute speed of generative organs formation	$AGRNg = (Ng_2 - Ng_1) / \Delta T$	pcs./day
Relative growth rate indicators		
Relative growth rate of total phytomass	$RGR = (\ln W_2 - \ln W_1) / \Delta T$	g/day
Relative growth rate of length	$RGRh = (\ln H_2 - \ln H_1) / \Delta T$	cm/day
Relative growth rate of the total mass of leaves	$RGRWL = (\ln WL_2 - \ln WL_1) / \Delta T$	g/day
Relative speed of leaf area formation	$RGRA = (\ln A_2 - \ln A_1) / \Delta T$	cm^2/day
Relative speed of leaf formation	$RGRNL = (\ln NL_2 - \ln NL_1) / \Delta T$	pcs./day

[1]Here and in Table 3, the lower index "1" indicates the results of the first dimension measurement; the lower index "2" indicates the results of the second dimension measurement; ΔT is the time between the first and second measurements.

Table 3. List of dynamic allometric morphoparameters that were used to estimate *Nymphaea candida* plant growth

Morphoparameters	Symbols and formulas of morphoparameters[1]	Units of measurement
Net-assimilation	$NAR1 = \frac{W_2 - W_1}{\Delta T} \times \frac{\ln A_2 - \ln A_1}{A_2 - A_1}$	g/cm²/day
	$NAR2 = \frac{2 (W_2 - W_1)}{(A_2 + A_1) \Delta T}$	g/cm²/day
Productivity of a leaf area forming	$LAR1 = \frac{A_2 - A_1}{\Delta T} \times \frac{\ln W_2 - \ln W_1}{\ln A_2 - \ln A_1}$	cm^2/g/day
	$LAR2 = \frac{A_2 - A_1}{\Delta T} \times \frac{\ln W_2 - \ln W_1}{W_2 - W_1}$	cm^2/g/day
	$LAR3 = \frac{A_2 - A_1}{W_2 - W_1} \times \frac{\ln W_2 - \ln W_1}{\ln A_2 - \ln A_1}$	cm^2/g/day

To evaluate the influence of the leading ecological-cenotic factors (water column, total plant cover, water transparency) on the values of the dynamic morphoparameters of *Nymphaea candida*, the dispersive analysis there was computed, accompanied by calculations of power of influence (Tsarenko et al., 2000).

RESULTS AND DISCUSSIONS

The values of the dynamic morphoparameters characterizing the growth rate processes in *Nymphaea candida* in the studied cenopopulations are shown in Table 4.

Dynamic metric morphoparameters. The highest absolute growth of phytomass (AGR) is observed in *Nymphaea candida* individuals in *Nymphaea candida* - *Potamogeton lucens* (32.7±3.99 g/day) and *Nuphar lutea* - *Ceratophyllum demersum* (25.4±3.75 g/day) communities. The lowest AGR value is observed in the cenopopulation of *Nymphoides peltata* - *Ceratophyllum demersum* community (1.9±0.47 g/day). In other cenopopulations, the growth of phytomass varies from 5.3±1.22 g/day to 13.3±3.73 g/day (Figure 1).

The values of absolute speed of leaf formation (AGRNL), absolute growth rate of its total mass (AGRWL), absolute growth rate of generative organs mass and number of generative organs (AGRWg and AGRNg, respectively), are the largest in *Nymphaea candida* - *Potamogeton lucens* individuals (0.43±0.045 pcs./day, 8.7±0.99 g/day, 3.4±0.55 g/day, 0.22±0.016 pcs./day, respectively), the smallest in *Numphoides peltata* - *Ceratophyllum demersum* individuals (0,10±0.012 pcs./day, 0.6±0.14 g/day, 0.3±0.08 g/day, 0.03±0.006 pieces/day, respectively). In other populations, the magnitudes of AGRNL parameters range from 0.13±0.008 pcs./day to

0.31±0.037 pcs./day, AGRWL - from 1.5±0.17 g/day to 8.3±1.26 g/day, AGRWg - from 0.4±0.06 g/day to 1.6±0.51 g/day, AGRNg - from 0.06±0.006 pcs./day to 0.13±0.025 pcs./day.

The highest absolute growth rate of leaf area (AGRA) is in individuals of *Nuphar lutea* - *Ceratophyllum demersum* community (190.8±28.67 cm²/day), the smallest in *Numphoides peltata* - *Ceratophyllum demersum* community (12.8±2.77 cm²/day). In other populations, the AGRA parameter ranges from 24.3±2.86 cm²/day to 142.3±16.23 cm²/day.

Table 4. Dynamic morphoparameters of *Nymphaea candida* in different ecological-coenotic conditions of the Desna basin reservoirs

Morphoparameters	Communities					
	Nuphar lutea + *Potamogeton natans*	*Nuphar lutea* - *Ceratophyllum demersum*	*Nymphaea candida subpurum*	*Nymphaea candida* - *Potamogeton lucens*	*Nuphar lutea subpurum*	*Nymphoides peltata* - *Ceratophyllum demersum*
	$\overline{X} \pm S_{\overline{x}}$	$\overline{X} \pm S_{\overline{x}}$	$\overline{X} \pm S_{\overline{x}}$	$\overline{X} \pm S_{\overline{x}}$	$\overline{X} \pm S_{\overline{x}}$	$\overline{X} \pm S_{\overline{x}}$
Dynamic metric morphoparameters						
AGR	5.8 ± 0.59	25.4 ± 3.75	13.3 ± 3.73	32.7 ± 3.99	5.3 ± 1.22	1.9 ± 0.47
AGRWL	1.5 ± 0.17	8.3 ± 1.26	4.7 ± 1.33	8.7 ± 0.99	1.6 ± 0.33	0.6 ± 0.14
AGRNL	0.13 ± 0.008	0.30 ± 0.028	0.31 ± 0.037	0.43 ± 0.045	0.14 ± 0.018	0.10 ± 0.012
AGRWg	0.4 ± 0.06	1.4 ± 0.31	1.6 ± 0.51	3.4 ± 0.55	0.6 ± 0.15	0.3 ± 0.08
AGRNg	0.06 ± 0.006	0.12 ± 0.027	0.13 ± 0.025	0.22 ± 0.016	0.07 ± 0.011	0.03 ± 0.006
AGRH	1.4 ± 0.05	2.2 ± 0.08	1.7 ± 0.06	2.4 ± 0.04	1.2 ± 0.05	0.7 ± 0.04
AGRA	24.3 ± 2.86	190.8 ± 28.67	99.2 ± 27.90	142.3 ± 16.23	29.8 ± 6.15	12.8 ± 2.77
RGR	0.06 ± 0.001	0.09 ± 0.002	0.10 ± 0.004	0.11 ± 0.002	0.06 ± 0.003	5.20 ± 0.210
RGRA	0.07 ± 0.001	0.12 ± 0.002	0.13 ± 0.004	0.14 ± 0.002	0.07 ± 0.002	7.10 ± 0.190
RGRWL	0.04 ± 0.001	0.08 ± 0.002	0.08 ± 0.004	0.09 ± 0.001	0.05 ± 0.002	0.04 ± 0.001
RGRNL	0.02 ± 0.001	0.04 ± 0.001	0.04 ± 0.001	0.05 ± 0.001	0.03 ± 0.001	2.40 ± 0.111
RGRh	0.05 ± 0.001	0.07 ± 0.001	0.07 ± 0.001	0.08 ± 0.001	0.05 ± 0.001	0.74 ± 0.040
Dynamic allometric morphoparameters						
NAR1	0.02 ± 0.001	0.04 ± 0.001	0.01 ± 0.001	0.04 ± 0.007	0.01 ± 0.001	0.01 ± 0.001
NAR2	0.006 ± 0.0001	0.009 ± 0.0001	0.004 ± 0.0003	0.009 ± 0.0001	0.004 ± 0.0001	0.002 ± 0.0001
LAR1	20.6 ± 2.49	166.3 ± 23.28	77.9 ± 22.58	122.6 ± 14.23	23.9 ± 5.15	9.8 ± 2.26
LAR2	0.21 ± 0.006	0.35 ± 0.050	0.70 ± 0.042	0.45 ± 0.099	0.31 ± 0.010	0.27 ± 0.012
LAR3	2.8 ± 0.07	2.9 ± 0.37	5.4 ± 0.29	3.3 ± 0.71	4.2 ± 0.14	4.4 ± 0.16

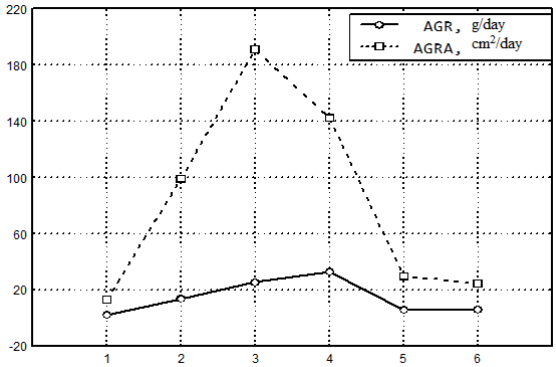

Figure 1. Dynamics of absolute growth rate of phytomass (AGR - g/day) and absolute growth rate of leaf area (AGRA - cm²/day) in populations of *Nymphaea candida* on a water column gradient (the numbering of the habitats corresponds to the Table 1)

In *Numphoides peltata* - *Ceratophyllum demersum* community, compared to *Nymphaea candida* - *Potamogeton lucens* community, the value of the AGR morphoparameter was decreased 17.2 times, AGRWL - 14.5 times, AGRNL - 4.3 times, AGRWg - 11.3 times, AGRNg - 7.3 times, and the magnitude of AGRA, compared to its largest value in the population community of *Nuphar lutea*–*Ceratophyllum demersum* - 14.9 times.

Factors of water column (depth), total plant cover, and bottom sediments showed statistically significant influence on all morphoparameters that characterize the absolute growth rate, influencing the levels of 63.4-94.6%, 23.6-53.4% and 12.6-46.9% (Table 5). The water transparency factor did not show a statistically significant influence on one indicator of absolute growth rate; for all others its floating power is 13.2-18.9%. The leading factor in determining the patterns of variation in absolute growth rate in *Nymphaea candida* is a water column.

The magnitudes of the morphoparameters of the relative growth rate of total phytomass (RGR) and leaf area (RGRA), respectively, range from 0.06±0.003 g/g/day to 5.20±0.210 g/g/day and from 0.07±0.002 cm²/cm²/day to

7.10±0.190 cm²/cm²/day (Figure 2). They are the highest in the population community of *Numphoides peltata - Ceratophyllum demersum*, while the smallest are in *Nuphar lutea subpurum* and *Nuphar lutea + Potamogeton natans* individuals.

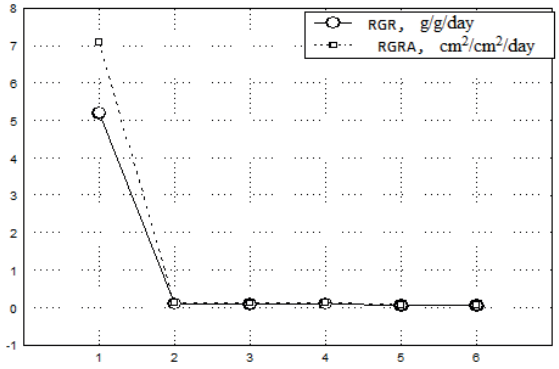

Figure 2. Dynamics of relative growth rates of phytomass (RGR - g/g/day) and relative growth rate of leaf area (RGRA - cm^2/cm^2/day) in *Nymphaea candida* cenopopulations on a water column gradient (the numbering of the habitats corresponds to the Table 1)

According to the values of relative growth rate of leaf phytomass (RGRWL), populations are divided into two groups. One includes coenopopulations of *Nymphaea candida - Potamogeton lucens*, *Nymphaea candida subpurum* and *Nuphar lutea - Ceratophyllum demersum* communities. They are characterized by relatively high RGRWL values (0.08±0.004 - 0.09±0.001 g/g/day). The second group includes coenopopulations of *Nuphar lutea subpurum*, *Nuphar lutea + Potamogeton natans* and *Numphoides peltata - Ceratophyllum demersum*. The values of RGRWL are smaller in 1.6-2.3 times and there are 0.04±0.001-0.05±0.002 g/g/day. The highest value of this indicator is in the individuals of the coenopopulations of the *Nymphaea candida - Potamogeton lucens* community, and the lowest is in the *Nuphar lutea + Potamogeton natans* and *Numphoides peltata - Ceratophyllum demersum* individuals. The highest values of the relative leaf formation rate (RGRNL) are found in the individuals of the *Numphoides peltata - Ceratophyllum demersum* community (2.40±0.111 pcs./pcs./day). The value of RGRNL in other four populations (in communities *Nuphar lutea subpurum, Nuphar lutea - Ceratophyllum demersum, Nymphaea candida subpurum, Nymphaea candida - Potamogeton lucens*) ranges from 0.03±0.001 pcs./day to 0.05±0.001 pcs./day. The lowest value of this morphoparameter (0.02±0.001 pcs./day) was detected in the community *Nuphar lutea + Potamogeton natans*.

Table 5. Influence of ecological-coenotic factors on the magnitude of morphoparameters of *Nymphaea candida*[1]

Morphparameter	Water column			Total plant cover			Bottom sediments			Water transparency		
	F-test	Confidence level	Factor influence force,%	F-test	Confidence level	Factor influence force,%	F-test	Confidence level	Factor influence force,%	F-test	Confidence level	Factor influence force,%
Dynamic metric morphoparameters												
AGR	26.0	0.0000*	75.2	6.8	0.0007*	31.1	10.6	0.0021*	18.4	4.1	0.0237*	15.0
AGRWL	21.9	0.0000*	71.8	7.1	0.0005*	32.2	10.7	0.0020*	18.5	5.0	0.0113*	17.7
AGRNL	26.0	0.0000*	75.1	9.5	0.0005*	38.8	12.5	0.0009*	21.0	5.3	0.0085*	18.7
AGRWg	14.9	0.0000*	63.4	4.6	0.0066*	23.6	6.7	0.0125*	12.6	3.5	0.0382*	13.2
AGRNg	21.0	0.0000*	70.9	7.3	0.0004*	32.6	13.4	0.0006*	22.3	3.6	0.0364*	13.2
AGRh	150.6	0.0000*	94.6	17.2	0.0000*	53.4	41.6	0.0000*	46.9	1.8	0.1735	7.3
AGRA	21.0	0.0000*	70.3	6.9	0.0006*	31.5	9.7	0.0031*	17.1	5.3	0.0082*	18.9
RGR	415.6	0.0000*	98.0	322.6	0.0000*	89.0	291.6	0.0000*	89.0	4.8	0.0133*	17.1
RGRA	871.2	0.0000*	99.0	512.8	0.0000*	90.0	427.5	0.0000*	89.5	4.8	0.0128*	17.3
RGRWL	95.3	0.0000*	91.7	16.3	0.0000*	52.0	24.8	0.0000*	34.5	5.2	0.0089*	18.6
RGRNL	300.4	0.0000*	97.2	282.9	0.0000*	87.2	306.7	0.0000*	87.2	4.7	0.0138*	17.0
RGRh	194.3	0.0000*	95.8	130.8	0.0000*	85.7	124.2	0.0000*	85.6	5.4	0.0081*	18.9
Dynamic allometric morphoparameters												
NAR1	18.2	0.0000*	67.8	5.3	0.0033*	26.0	11.0	0.0018*	18.9	2.1	0.1289	8.5
NAR2	13.4	0.0000*	63.2	4.5	0.0072*	24.1	9.5	0.0033*	16.4	2.1	0.1334	8.0
LAR1	23.4	0.0000*	73.2	6.8	0.0007*	31.1	9.7	0.0032*	17.0	5.2	0.0090*	18.5
LAR2	13.4	0.0000*	68.2	26.2	0.0000*	63.6	4.5	0.0400*	8.7	5.5	0.0070*	19.4
LAR3	10.3	0.0000*	54.4	12.3	0.0000*	45.0	1.8	0.1820	5.3	5.0	0.0112*	17.7

[1]The mark * identifies morphoparameters, for which the factor showed statistically significant influence ($p < 0.05$)

The highest values of all indicators of relative growth rate were registered in the *Numphoides peltata - Ceratophyllum demersum* community and the lowest values (in most cases) were registered in the *Nuphar lutea + Potamogeton natans* community. The rates of relative growth rate in *Nymphaea candida* are low in variation. All the ecological-cenotic factors studied showed a statistically significant influence on the value of all indicators of relative growth rate. However, the influence of the factors was different: water column 91.7-99.0%, total plant cover 52.0-90.0%, bottom sediments 34.5-89.5%, water transparency 17.0-18.9%. The most significant influence on this group indicators has a water column.

Dynamic allometric morphoparameters. The highest values of net-assimilation (NAR1) are found in the coenopopulations of the *Nuphar lutea -Ceratophyllum demersum* and *Nymphaea candida - Potamogeton lucens* (0.04±0.007 g/cm^2/day). The NAR1 value is 0.02±0.001 g/cm^2/day in the *Nuphar lutea + Potamogeton natans* community. Specimens of the coenopopulations of the *Nymphaea candida subpurum*, *Nuphar lutea subpurum* and *Numphoides peltata - Ceratophyllum demersum* have the lowest values of this morphoparameter (0.01±0.001 g/cm²/day).

The highest values of net-assimilation (NAR2) were observed in the *Nymphaea candida - Potamogeton lucens* and *Nuphar lutea - Ceratophyllum demersum* (0.009±0.0001 g/cm²/day) communities, and the smallest were observed in *Numphoides peltata - Ceratophyllum demersum* (0.002±0.0001 g/cm²/day). In the *Nuphar lutea subpurum, Nymphaea candida subpurum* and *Nuphar lutea + Potamogeton natans* communities, the values of NAR2 range from 0.004±0.0003 g/cm²/day to 0.006±0.0001 g/cm²/day.

The rates of leaf area formation productivity (LAR1, LAR2, LAR3) vary over a wider range than net-assimilation. The highest LAR1 value is in individuals of the cenopopulation of the *Nuphar lutea - Ceratophyllum demersum* community (166.3±23.28 cm^2/g/day), the lowest is in the *Numphoides peltata - Ceratophyllum demersum* (9.8±2.26 cm²/g/day) which is 17.0 times less. The highest values of LAR2 and LAR3 are in individuals of the cenopopulation of the *Nymphaea candida subpurum* community (0.70±0.042 cm²/g/day and 5.4±0.29 cm²/g/day, respectively), the smallest values are in *Nuphar lutea + Potamogeton natans* (0.21±0.006 cm²/g/day and 2.8±0.07 cm²/g/day, respectively), which is 3.3 and 1.9 times smaller, consequently.

The factors of the water column and total plant cover showed a statistically significant effect on all dynamic allometric morphoparameters, affecting the levels of 54.4-73.2% and 24.1-63.6%, respectively. The bottom sediments and the water transparency did not have a statistically significant effect, respectively, on one (impact force 8.7-18.9%) and two morphoparameters (impact force 17.7-19.4%). The leading factor that determines the patterns of variation of dynamic allometric morphoparameters in *Nymphaea candida* is the water column. Dynamic morphoparameters in *Nymphaea candida* have a low level of variation. For most morphoparameters, the variance and standard deviation values are smaller than one.

The data obtained from the study of the growth characteristics of *Nymphaea candida* are agreement with the growth information of other aquatic plant species: *Trapa natans* and *Potamogeton natans* (Skliar, 2017; Skliar & Skliar, 2017). In particular, they argue that dynamic morphological parameters are important indicators of the macrophyte populations condition. According to their values, habitats and (or) reservoirs, is possible to differentiate by the degree of favorable for the functioning of populations of these species and, on this basis, to develop approaches for the protection of aquatic plants and, if necessary, the principles of their sustainable, inexhaustible economic use.

CONCLUSIONS

In *Nymphaea candida*, the rate of growth processes varies substantially depending on the growing conditions. An analysis of the effects of the leading ecological-cenotic factors showed that in the study area, the water column and the total plant cover of phytocenosis statistically significantly influence all the dynamic (metric and allometric) morphological parameters of *Nymphaea candida* plants. The

influence of these two factors is 54.4-99.0% and 23.6-90.0%, respectively.

The bottom sediment characteristics did not show a statistically significant effect on only one dynamic allometric morphoparameter (LAR3), and the influence of this factor on all other dimensional features of *Nymphaea candida* plants varied within 8.7-89.5%. Water transparency did not show a statistically significant effect on three morphoparameters (one metric - AGRH, two allometric - NAR1, NAR2) with the influence of this factor on all other features at the level of 13.2-19.4%. Thus, taking into account the set of indicators characterizing the effect on the growth of *Nymphaea candida* plants, the studied ecofactors form the following series (in order of increasing magnitude and significance): water transparency → bottom sediments → total plant cover →water column.

In the study region in plants of *Nymphaea candida* the highest values of most (58.8%) dynamic morphoparameters are registered in the community *Nymphaea candida* - *Potamogeton lucens.* The smallest values of most morphological parameters (64.7%) are registered in the community *Numphoides peltata - Ceratophyllum demersum*.

At the same time, plants of *the Numphoides peltata - Ceratophyllum demersum* community exhibit the highest magnitudes of almost all (four out of five) indicators of relative growth rate.

The fastest growth of *Nymphaea candida* plants is in the areas where there is no flow, the water column varies within 50-100 cm, the water transparency reaches the bottom, the silt bottom sediments are represented, and the total plant cover of phytocenosis is 60-85%. The projective coverage of *Nymphaea candida* can range from 10% to 40%. Such habitat conditions are optimal to ensure the continued existence of populations of this species as a whole.

Accordingly, the introduction of active measures for the protection of populations of *Nymphaea candida* in certain reservoirs (their areas) should be oriented towards the achievement of such a complex of ecological-cenotic characteristics.

REFERENCES

Belavskaya, A.P. (1982). The main problems of studying aquatic vegetation of the USSR. *Botanical Journal*, 67(10), 1313-1320 (in Russian).

Dubyna, D.V. (1975). On the morphological differences of *Nymphaea alba* L. and *N. candida* Presl. in Ukraine. *Ukrainian Botanical Journal*, 32(6), 778-782 (in Ukrainian).

Dubyna, D.V. (2006). *Higher aquatic vegetation*. Kyiv, Fitosotsiotsentr (in Ukrainian).

Dubyna, D.V. (1982). *Water Lily of Ukraine*. Kiev, Naukova dumka (in Russian).

Dubyna, D.V., Stoiko, S.M., Sytnik, K.M., Tasenkevich, L.A., Shelyag-Sosonko, Yu.R., Heyna, S., Groudova, Z., Gusak, Sh., Otyagelova, G. & Erzhabkova O. (1993). *Macrophytes - indicators of environmental changes.* Kiev, Naukova dumka (in Russian).

Heidan, K.P. (1965). A study of the morphology of *Nymphaea candida* J. et C. Presl (white water lily) compared with *Nuphar luteum* (L.) Smith (yellow capsule). *Proceedings of the Leningrad Chemical-Pharmacological Institute*, 3, 63-65 (in Russian).

Hejny, S. (1960). *Ökologische Charakteristik der Wasser – und Sumpflanzen in der slowakischen Tiefebenen*. Bratislawa.

Hunt, R. (1978). *Plant growth analysis*. London.

Klymenko, H.O. & Skliar, V.H. (2015). Features of plant growth of rare species. *Bulletin of Sumy National Agrarian University. Series: Agronomy and Biology*, 9(30), 77-82 (in Ukrainian).

Morozova, G.Yu. (2009). Urban Monitoring: Plant Population Structure. *Bulletin of the Samara Center of the Russian Academy of Sciences*, 11(1-6), 1170-1173 (in Russian).

Scherbakova, O.F. & Novosad, K.V. (2013). Features and seasonal development of multivariate structure of annual flowering shoots of *Pulsatilla patens* (L.) Mill. and *P. pratensis* (L.) Mill. in Kyiv megapolis. *Plant introduction*, 3, 34-42 (in Russian).

Skliar, Iu.L. (2006). Population structure of *Nymphaea candida J. et C. Presl.* of the Desna basin within the North-East of Ukraine. *Ukrainian Botanical Journal*, 63(4), 495-501 (in Ukrainian).

Skliar, Iu.L. & Skliar, V.H. (2017). Growth characteristics of *Trapa natans* L. s. l. in different ecological-cenotic conditions of the reservoirs of the Desna basin. *Ukrainian Journal of Ecology*, 7(3), 239-245 (in Ukrainian).

Skliar, Iu.L. (2017). Growth characteristics of *Potamogeton natans* L. in different ecological-cenotic conditions of the reservoirs of the Desna basin. *Lesya Ukrainka Eastern European National University Scientific Bulletin. Series: Biological Sciences*, 7(356), 47-55. DOI: https://doi.org/10.29038/2617-4723-2017-356-7-47-55 (in Ukrainian).

Skliar, V.H. & Zlobin, Yu.A. (2013). Intrapopulation structure and methodology of its study in woody forest-forming species. *Chernomorsk. Botanical Journal*. 9(3), 316-329 (in Ukrainian).

Tsarenko, O.M., Zlobin, Yu.A., Skliar, V.H. & Panchenko, S.M. (2000). *Computer methods in*

agriculture and biology. Sumy, University book (in Ukrainian).

Zlobin, Yu.A. (1989). *Principles and methods of studying coenotic plant populations*. Publishing house of Kazan Federal University (in Russian).

Zlobin, Yu.A. (1992). Population - a unit of real plant life. *Nature*, 8, 47-59 (in Russian).

Zlobin, Y.A., Skliar, V.G., Bondareva, L.M. & Kyrylchuk, K.S. (2009). Concept of morphometry in modern botany. *Chernomorsk. Botanical Journal*, 5(1), 5-22 (In Ukrainian).

***List of species of plants, animals and mushrooms subject to special protection in the Sumy region. Approved by the Decision of the Sumy regional council of 18.11.2011, "On measures to strengthen the protection of rare and endangered species of plants, animals and fungi subject to special protection in the Sumy region", 19 p.: http://knt.sm.gov.ua/index.php/ru/ogoloshennya/5001-perelik-vidiv-roslin-tvarin-i-gribiv-shcho-pidlyagayut-osoblivij-okhoroni-na-teritoriji-sumskoji-oblasti (in Ukrainian).