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AGE AND GROWTH COMPARISON OF DIPLOID AND TRIPLOID SPECIES OF CRUCIAN CARPS (CYPRINIFORMES, CYPRINIDAE) IN THE WATER BODIES OF THE DNIPRO BASIN

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Age and Growth Comparison of Diploid and Triploid Species of Crucian Carps (Cypriniformes, Cyprinidae) in the Water Bodies of the Dnipro Basin. Kokodiy, S. V. — The genetic structure of crucian carps colonies in Ukrainian water bodies was defined by gene marking. The sexual structure and ploidy were investigated, the duration of spawners maturation, life-span, rate of growth and the linear growth of independent species and biotypes were defined. The comparative biological analysis showed that virtually all the researched crucian carps had low linear growth index and early maturation terms. The hybrid individuals of C. *auratus*–*C. carassius* during the first years of life were characterized by the high rate of growth which was most likely determined by the "hybrid power" which is kept by this biotype only within the starting phase of existence, after which the active growth is significantly reduced. The individual biological peculiarities of peculiar species and biotypes of crucian carps do not depend on their genetic nature but in most cases are defined by the external living conditions.
Key words: growth, growth rate, species, biotype, the Chinese crucian carp, C. *auratus*, the Prussian carp, C. *gibelio*, the Crucian carp, *C. carassius*.

Introduction

Increased scientific interest of researchers to the representatives of genus *Carassius* became clear in the second half of the 20th century. The reason for that was the broad introduction of the East Asian Prussian carp, *C. auratus* s. l., into European water bodies. In 1960th for the increase of fish capacity, the Prussian carp, *C. gibelio* (Bloch.), was settled into the first order streams together with herbivorous prime fish species. After the establishment of numerous water storage reservoirs on the Dnipro River the arrangements aimed at acclimatization of Far Eastern fish species were actively implemented in Ukraine. As a result the Prussian carp appeared in numerous water bodies and soon became one of the primary commercial species (Mezhzherin, 2008).

The species status of the Prussian carp was unclear due to the lack of research on karyology and gene marking. After the in-depth research of the genetic structure and biological peculiarities of the Prussian carp, *C. gibelio* it turned out that there were at least 2 species under one subspecific name. They could not be diagnosticated by exterior marks. The early research of the Prussian carp showed that it was able to make the unisexual colonies, which were represented only by the females, and bisexual ones with the equal number of males and females (Sysoeva, 1958; Holčík, 1978, 2003; Lusk et al., 2003).

The attempts to divide the Prussian carp into separate species were taken repeatedly. Originally the morphological analysis was the principal diagnostic method for the identification of species. Multiple attempts were taken to identify the Prussian carp from different water bodies not only by the exterior marks but by the

kind of scale covering, the peritoneum color, the size of red blood cells and other marks (Goriunova, 1974; Kharitonova, 1963; Golovinskaya et al., 1965). However, such identification did not give an opportunity for distinct separation of species and for giving them a biological characteristic. The crucian carps from different water bodies varied in color, body shape and other marks. As a result different species of crucian carps were united into one species *C. gibelio*, and in other sources into C. *auratus*, or were separated into different species incorrectly and consequently their biological diagnosis was wrong. Usually it was general and suitable for the both species (Abramenko et al., 1997).

According to the latest fish systematics reports (Bogutskaya, Naseka, 2004; Kottelat, 1997) Eastern Europe is inhabited by three species: amphimictic diploid crucian carp, *C. carassius*, apomictic triploid Prussian carp, *C. gibelio* and amphimictic diploid Chinese crucian carp, *C. auratus*. The analysis of available data related to European crucian carps and especially to *C. gibelio* — triploid unisexual species, showed that the issue is much more complicated than it was considered earlier, since the number of species and hybrid forms may be much larger (Mezhzherin, Kokodiy, 2010). Moreover it was found out that *C. auratus* and *C. carassius* hybridize easily, making different ploidy biotypes (Kokodiy, 2010). Therefore despite the obvious progress in studying this issue, a range of problems, related to systematics, origin, distribution and studying biological peculiarities of species and biotypes of the genus *Carassius*, remains unsolved. The confusion in the determination of the crucian carps species in a great number of scientific publications related to studying growth rate of crucian carps and some aspects of reproduction process does not make it possible to give a detailed biological characteristic of separate species and biotypes of crucian carps.

In this relation there is a necessity to conduct the detailed scientific research devoted to studying biological peculiarities of particular species and biotypes of representatives of the genus *Carassius*.

Material and methods

The basis for research was the series of crucian carps samples — 1005 specimens, collected in 2006–2011 in spring-autumn periods from 30 water bodies belonging to the Dnipro catchment basin. It is worthwhile to say that the gene marking and cytometric analysis of crucian carps were conducted earlier and the research results were published (Mezhzherin, Kokodiy, 2010). This publication is aimed at determination of biological peculiarities of species and biotypes which are mostly not distinguishable morphologically, and can be identified only by the gene marking.

The age was determined in a standard way by the age rings on the fish scales (Pravdin, 1966). The gender was identified by the presence of female or male genital products, sexual maturity according to the gonads' development. Special attention was paid to various deviations in gonads' development and the genital products' condition of hybrid zooids. The crucian carps' bodies were measured in a standard way (Pravdin, 1966). Linear growth gain and growth rate were calculated by the logarithmic scale method of G. N. Monastyrskiy. The collected data was processed by the Exel and Past programmes.

Results and discussion

Colonies structure according to species and biotypes. The genetic markers and cytometry, which were described in detail in the early researches (Mezhzherin, Kokodiy, 2010), gave and opportunity to split all the investigated crucian carps into the following species and biotypes: *Carassius auratus*, *Carassius carassius*, *Carassius gibelio*-1, *Carassius gibelio*-2, *Carassius gibelio*-3, *Carassius gibelio*-4 and hybrids of crucian carp with the Chinese crucian carp, *Carassius carassius-auratus*, and the hybrids of the Chinese crucian carp with the Prussian carp — *Carassius auratus-gibelio*-2 (table 1).

Sexual structure. It is worthwhile to divide all species and biotypes into the following two basic groups: bisexual and unisexual crucian carps. The first group includes individuals of the Crucian carp, *C. carassius*, the Chinese crucian carp, *C. auratus,* and hybrids *C. auratus–carassius*. As a rule the quantity of females and males in the colonies of the Chinese crucian carp and the Crucian carp is equal. In some selections the sex ratio of *C. auratus* was in favor of males, whose share was 63–64 % (Grafskoye lake-2, location Vetkhoye-2) of all the studied crucian carps. According to our observations the increase of males' share in the population of crucian carps can be observed in the dystrophic waters with oligotrophic trophic base and poor oxygen regimen. As a rule in favorable habitability conditions the sex ratio is either equal or the number of females in the colonies is slightly larger.

The sexual structure of hybrid zooids of *C. auratus–carassius* in the researched colonies has a direct correlation to crucian carps ploidy. In the diploid hybrid colonies the

Table 1. Collection places of the selections and species structure of crucians colonies in water bodies of the Dnipro basin

Selection	Coordinates	*C. auratus*	*C. carassius*	*C. gibelio-1*	*C. gibelio-2*	*C. gibelio-3*	*C. gibelio-4*	*C. auratus- carassius*	*C. auratus- gibelio-2*
Grafskiy-1	51°03′/31°51′	50	2	2	2			1	3
Grafskiy -2	51°03′/31°51′	68			17				
Loc. Vetkhoye-1	51°03′/31°49′	2		5	33				
Loc. Vetkhoye-2	51°05′/31°81′	110		4	1	8		5	
Loc. Vetkhoye-3	51°06′/31°80′	15		2	3				
Loc. Vetkhoye-4	51°04′/31°80′	18							
Loc. Vetkhoye-5	51°05′/31°49′	18							
Loc. Vetkhoye-6	51°04′/31°50′	15		1					
Vil. Perebudova	51°01′/32°04′			20					
Vil.Kunashevka-1	51°02′/32°00′	11		1	3				5
Vil.Kunashevka-2	51°02′/32°00′	11		1	4				4
Vil. Yadury	51°22′/32°20′	46	30	2	17			34	5
Vil. Ochkino-1	52°13′/33°22′		2	42					
Vil. Ochkino -2	52°12′/33°22′		10						
Vil.Krenidovka	52°14′/33°27′			30					
Vil. Mefedovka	52°16′/33°27′			20					
Vil.Bodenky	50°50′/30°45′	12							
Vil. Hibalovka	51°23′/31°51′	2	4					1	
Vil. Palyvody	51°00′/31°59′		8	10				3	
Vil. Lesniki	50°17′/30°29′	16	25				25	5	1
Vil. Spartak	50°39′/28°59′	40	4		1			3	
Korosten	50°94′/28°36′			7				62	
Cherkassy	49°26′/32°04′		2	35					
Lake Pogoreloye-Pervoye	46°36′/32°33′	24							
Lake Koshevaya	46°36′/32°28′	20							
Lake Rvach-Litvinka	46°32′/32°19′	18							
Lake Shkadovsk-Pogoreloye	46°35′/32°31′	12							
Nezhin	50°99′/31°89′	20							
Vil. Kachanovka	50°51′/32°38′	12		2	5				
Vil. Lesovoy	51°54′/32°28′			20					

number of females considerably exceeds the number of males and in triploid colonies the sex ratio is equal.

The triploid individuals of clone biotype *C. gibeli*-2 should be counted as bisexual crucian carps. In the colonies of these crucian carps triploid males which take part in reproduction are found (location Vetkhoe-2). Underdeveloped spermatozoa of such triploid males probably initiate egg cell division of C. *gibelio*-2 females (Cherfas, 1966).

The second group consists of Prussian carps, whose colonies are represented exclusively by triploid females with matroclinal inheritance: *C. gibelio*-1, *C. gibelio*-3, *C. gibelio*-4, and hybrid non-clone specimens *C. auratus-gibelio*-2. The clone biotype *C. gibelio*-1 is capable of forming its own unisexual colonies. The other Prussian carp's biotypes can be encountered in common populations with *C. auratus*; its males, apparently, take part in common reproduction (table 1).

In general species and biotypes selection there is a distinct dependence of ploidy from gender. In the polyploid crucian carps' populations the colony consists mostly of females, and in the diploid species and some populations of hybrids between the Crucian carp and the Chinese crucian carp the ratio of sexes is almost equal (table 2).

Spawners maturity. According to our observations the sexual maturity of crucian carps depends on habitability conditions and does not apply to species and biotypes

Table 2. Sex ratio, ploidy of crucians species and biotypes

Data	*C. carassius*	*C. auratus*	*C. auratus–carassius*	*C. gibelio-1*	*C. gibelio-2*	*C. gibelio-3*	*C. gibelio-4*	*C. auratus–gibelio-2*
n	2n	2n	2–3n	3n	3n	3n	3n	3n
N	84	477	104	172	74	8	3	15
♀, %	56	50.7	69	100	95.9	100	100	100
♂, %	44	49.3	31	0	4.1	0	0	0

Note. The juvenile and atocous specimens were excluded from analysis.

separately. Apparently, the unfavorable habitability conditions form the prime factor which influences the precocious sexual maturation of spawners of different species and biotypes. It causes the overpopulation of water bodies with small stunted fish. However, in favorable habitability conditions the species, in particular the Crucian carp, *C. carassius,* and Chinese crucian carp, *C. auratus,* have some differences in terms and periods of spawning and the first sexual maturation (Astanin, Podgornyi, 1963).

The growth rate and the linear growth index of the Prussian carp, *C. auratus* s. l., in Ukrainian water bodies are the same as the ones of the Prussian carp from the Amur basin. In the water bodies of the Amur basin, alongside with rapidly increasing populations of crucian carps, there are also stunted populations of this species which have the same rate and speed of growth as the ones in the Dnipro basin. They also coincide with the literature data related to crucian carps of Ukrainian water bodies. (Sysoyev, 1958; Movchan, Smirnov, 1983). In this relation it's worth noting that unfavorable living conditions: poor trophic base, overpopulation and poor oxygen regimen, which causes winter and summer suffocation of fish, result in early and simultaneous maturation of different species and biotypes in unfavorable conditions. In stunted colonies the investigated crucian carps' species and biotypes reach the reproductive age at 2+ when their body length is 73–84 mm (Spartak railway station, location Vetkhoye-2, location Vetkhoye-4, creek Koshevaya, creek Rvach-Litvinka, lake Shkadovsk-Pogoreloye). The crucian carps from mentioned above water bodies had low linear growth index. In other researched selections the spawners start egg-laying at the age of 3+ and 4+.

Not depending on species and researched water bodies, the males become sexually mature earlier than females. In water bodies where winter and summer suffocations of fish take place, the males become sexually mature for the first time at the age of 2+, and females at the age of 3+. In more favourable conditions the sexual maturity takes place one year later: the males become sexually mature at the age of 3+ and females at the age of 4+. However, on the basis of these figures, the individuals from given selections should be counted as crucian carps with low linear growth index, since the spawners with higher linear growth index from other water bodies become sexually mature much later, at the age of 4+ and 5+ (Sysoyeva, 1958).

There is some evidence that in common colonies the first sexual maturation of the crucian carp takes place one year earlier than of the Chinese crucian carp (Astanin, Podgornyi, 1963). However, during our research we did not discover such discrepancies. As it turned out, in stunted colonies the spawners of two species become sexually mature at the age of 2+ (males) and 3+ (females). In common colonies where the crucian carps of the two species had higher linear growth index, the spawners became sexually mature for the first time one year later at the age of 3+ (males) and 4+ (females).

In the similar type water bodies with separate colonies the spawning of crucian carp, *C. carassius,* takes place much later than of the Chinese crucian carp, *C. auratus*. For instance, the first portion of fish eggs is laid by the Chinese crucian carp in late April–early May and this process if finished in the middle of the month. The spawning process of the Crucian carp starts in the middle of the month and the first portion of fish is laid till the end of May. On the condition of two species coexistence the spawning process takes

Table 3. Age and body length of crucian carp species and biotypes in general selection

Species, biotype	Age, years and body length, mm																					
	2		3		4		5		6		7		8		9		10		11		12	
	M	± m	M	± m	M	± m	M	± m	M	± m	M	± m	M	± m	M	± m	M	± m	M	± m	M	± m
C. carassius	49.8	–	79.8	3.5	102.0	–	133.0	3.9	146.7	7.0	154.7	2.5	176.3	4.8	187.4	11.4	228.0	–	–	–	244.0	–
C. auratus	69.8	3.1	98.8	1.1	108.2	1.6	131.0	2.8	147.4	3.3	161.0	3.1	178.3	2.5	198.7	13.0	239.5	3.4	176.0	–	–	–
C. auratus–carassius	–	–	87.0	4.6	88.0	5.2	123.0	9.0	151.0	3.3	162.0	2.9	172.0	3.1	179.0	5.7	224.0	2.5	–	–	254.0	–
C. gibelio-1	82.0	2.1	100.0	1.7	114.0	3.7	118.0	3.1	130.0	4.1	153.0	6.3	190.0	8.7	206.0	9.9	213.0	13.2	–	–	–	–
C. gibelio-2	79.0	1.2	107.0	5.4	119.0	1.2	140.0	2.6	160.0	5.6	174.0	4.1	182.0	–	183.0	–	–	–	–	–	–	–
C. gibelio-3	–	–	97.0	0.6	117.0	4.2	128.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
C. gibelio-4	–	–	93.0	2.4	–	–	–	–	136.0	4.5	–	–	155.0	–	–	–	–	–	–	–	–	–
C. auratus–gibelio-2	–	–	94.0	7.7	117.0	3.2	153.0	–	–	–	169.0	1.2	184.0	10.5	–	–	–	–	–	–	–	–

place simultaneously which may cause the appearance of cross-species hybrids. Apparently, in this case the spawning process and hormonal activity of the Chinese crucian carp, *C. auratus,* acts as accelerating agent of spawning start for the later species — the Crucian carp, *C. carassius*.

It was interesting to discover the sterile individuals, which were counted as sexually mature pursuant to body measurements. Among all the investigated crucian carps 15 grown up individuals were agamous. The Prussian carp, *C. auratus* s. l., has the same tendency which was discovered by the other researchers in earlier works (Sysoyeva, 1958).

Growth. The length frequency comparison of all researched species and biotypes of crucian carps in total selection turned out to be very interesting (table 3; fig. 1). The highest linear growth rate in total selection belonged to clone biotypes *C. gibelio*-2 and *C. gibelio*-1. The linear growth rate of the Crucian carp and the Chinese crucian carp turned out to be a little lower. The rest of clone biotypes of the Prussian carp and hybrids had the smallest linear growth index. The linear growth figures of the Chinese crucian carp, *C. auratus* proved to be ambiguous from the samples. In nine studied reservoirs, inhabited only by specimens of *C. auratus*, the groups of carp with high rates of linear growth and stunted fish were found (table 4). The Chinese crucian carp from the Dnipro Delta had higher linear growth index (lake Pogoreloye-Pervoye, lake Shkadovsk-Pogoreloye). The collected data coincide with the linear growth index of crucian carps from the Amur basin (Sysoyeva, 1958). The Chinese crucian carps from the majority of the studied water bodies were characterized by the retarded growth; according to the external features the water bodies were similar and categorised as dystrophic. The crucian carps from location Vetkhoye-4, Nezhin town, lake Grafskoye had the lowest growth rate index. It is probably caused by the frequent winter-and-summer suffocations of fish, poor trophic base and overpopulation. Unfavourable periods could be clearly traced by the additional age rings on the fish scales of the investigated individuals.

The growth rate of *C. auratus* from the selections is also ambiguous. Only in a few studied water bodies, apparently, due to the stable living conditions, after few years of active growth the annual growth rate gradually decreased. It may be caused by the growth slow-up after completion of sexual maturation (town Nezhin, lake Grafskoye-1, creek Koshevaya, lake Shkadovsk-Pogoreloye) (table 5). In other water bodies the situation was different; the annual growth rate of Chinese crucian carps had no distinct annual regu-

Table 4. Veracious linear growth index values from selections of the Chinese crucian carp, *C. auratus*

Selections	1	2	3	4	5	6	7	8	9
1	X	0,6	**0.02**	0.7	0.3	0.7	**0.00**	**0.004**	0.1
2	–	X	**0.01**	0.9	0.5	0.6	**0.00**	**0.007**	0.3
3	–	–	X	0.08	**0.03**	0.5	**0.00**	**0.0003**	**0.008**
4	–	–	–	X	0.5	0.6	**0.00**	**0.003**	0.3
5	–	–	–	–	X	0.4	**0.01**	0.14	0.9
6	–	–	–	–	–	X	**0.002**	**0.02**	0.4
7	–	–	–	–	–	–	X	0.6	**0.002**
8	–	–	–	–	–	–	–	X	0.1
9	–	–	–	–	–	–	–	–	X

Note: 1 — lake Grafskoye-1; 2 — location Vetkhoye; 3 — lake Pogoreloye-Pervoye; 4 — creek Koshevaya; 5 — creek Rvach-Litvinka; 6 — lake Shkadovsk-Pogoreloye; 7 — lake Grafskoye-2; 8 — Nezhin; 9 — location Vetkhoye. Veracious values ($p < 0.05$) are marked with bold type.

lar decrease with advancing age. In some selections (location Vetkhoye-2, creek Rvach-Litvinka) the growth of crucian carps was uneven which may be caused by different living conditions during different periods. The factor of favorable or unfavorable living conditions is definitely of great importance not only for first sexual maturation's terms shifting for the later or earlier ones, but it influences greatly the growth of Chinese crucian carps in different years. The uneven annual gains of Chinese crucian carps from different selections prove that fact (lake Pogoreloye-Pervoye, lake Grafskoye-2).

The first sexual maturation of crucian carps with high linear growth index (lake Pogoreloye-Pervoye) did not cause the reduction of annual gain and on the contrary this characteristic gradually increased (table 5). Unfortunately, due to the availability of individuals representing the middle age group only, it is impossible to trace the annual gain in all the age groups in-detail, in order to estimate exactly the growth rate of crucian carps from year to year, for determination of periods with low and high linear growth rate. Such data would give an opportunity to estimate the influence of internal and external factors on growth rate and periods of spawners maturation not only of the Chinese crucian carp but of other species as well.

The annual growth rate of different species and biotypes of crucian carps from the similar type water bodies are slightly different. In the selections of the Crucian carp, *C. carassius*, the Prussian carp, *C. gibelio-1,* and the Chinese crucian carp, *C. auratus,* the annual gains are uneven. In the hybrid colonies of *C. auratus–C. carassius* the linear growth is the most intense within the first 2–3 years (table 6). The hybrids during the initial period of life have the most intense gain comparing to other species and biotypes, it may be caused by the hybrid nature of these specimens. Despite the amphidiploid structure of parental spe-

Table 5. Annual amount of growth of the Chinese crucian carp, *C. auratus*

Selections	Annual amount of growth, mm				
	11	12	13	14	15
Grafskiy-1	–	23.8	20.2	20.0	13.7
Vetkhoye-2	–	22.7	15.5	29.8	21.0
Pogoreloye-Pervoye	–	–	28.3	43.6	–
Koshevaya	26.0	17.0	15.0	–	–
Rvach-Litvinka	–	10.4	24.3	–	–
Skadovsk-Pogoreloye	–	–	33.4	13.1	–
Grafskoye-2	–	9.2	9.5	12.9	–
Nezhin	17.9	6.3	–	–	–
Vetkhoye-4	7.3	17.7	18.0	–	–

cies, which participated in hybridization process, the newly emerged species do not lose the "hybrid power". These regularities are not new; they were confirmed by other researches (Kirpichnikov, 1987). However, during the subsequent years of life (4–5 years) the growth speed of this biotype of crucian carps gradually decreases and does not differ from the one of other species. In this particular case the reduction of liner growth index can be caused by the first sexual maturation, which slows the growth rate.

Table 6. Linear growth of species and biotypes in similar type colonies

Species, biotype	Annual amount of growth, mm							
	11	12	13	14	15	16	17	l8
C. carassius	30.0	22.2	31.0	21.7	–	29.6	11.1	–
C. auratus	29.0	9.4	22.8	16.4	13.6	17.3	20.4	–
C. auratus–carassius	–	–	35.0	28.0	11.0	10.0	7.0	–
C. gibelio-1	18.0	14.0	4.0	12.0	23.0	37.0	16.0	7.0

The growth rate comparison of males and females of the following crucian types: *C. carassius*, *C. auratus* and of hybrid individuals *C. auratus–C. carassius* in general selection displayed distinct differences between all species and biotypes with no exceptions (table 7). According to our data the females grow a bit faster than males. As a rule the females are represented in a selection by larger specimens.

The linear growth index of males and females, representing various species and biotypes, was slightly different in the age groups. The distinct differences were discovered in the specimens representing Chinese crucian carp, *C. auratus,* and hybrid individuals which emerged after hybridization of the Crucian carp, *C. carassius,* and Chinese crucian carp, *C. auratus,* at the age of 5–6 years (table 8). In other age groups no distinct differences were discovered.

Table 7. Linear growth of females representing various species and biotypes in age groups in the context of comparison

Age, years	Species / Biotype											
	C. aur / *C. gib*-1		*C. aur* / *C. gib*-2		*C. aur* / *C. aur-caras*		*C. gib*-1 / *C. gib*-2		*C. aur* / *C. caras*		*C. caras* / C. *gib*-1	
	t	p	t	p	t	p	t	p	t	p	t	p
2	1.4	0.18	2.3	**0.01**	–	–	–	–	–	–	–	–
3	0.5	0.64	1.6	0.13	1.6	0.13	1.5	0.15	–	–	–	–
4	2.0	**0.05**	4.2	**0.000**	–	–	1.3	0.22	–	–	–	–
5	0.52	0.6	3.45	**0.002**	–	–	7.2	**0.0008**	3.4	**0.002**	4.7	**0.0001**
6	2.3	0.025	2.4	0.1	2.1	**0.03**	4.1	**0.0006**	0.4	0.7	2.6	**0.014**
7	0.9	0.3	1.6	0.12	0.07	0.9	2.1	**0.04**	1.02	0.31	2.1	**0.045**
8	0.06	0.7	–	–	0.28	0.3	–	–	2.4	**0.03**	–	–

Note. Veracious values are marked with bold type.

Table 8. Linear growth of females and males in age groups in the context of comparison

Age, years	Species / Biotype					
	C. auratus ♂ / ♀		*C. carassius* ♂ / ♀		C. *auratus-carassius* ♂ / ♀	
	t	p	t	p	t	p
3	0,95	0.35	–	–	0.14	0.89
4	0.08	0.93	–	–	–	–
5	1.7	**0.015**	0.83	0.44	2.9	**0.05**
6	0.97	0.27	0.8	0.4	3.8	**0.0006**
7	0.6	0.59	0.19	0.85	0.2	0.84
8	–	–	1.27	0.23	1.4	0.36
9	–	–	0.7	0.5	–	–

Note. Veracious values are marked with bold type.

After growth rate comparison of females representing different species and biotypes in age groups, it turned out that the clone biotype specimens of *C. gibelio*-1 and *C. gibelio*-2 had the largest linear growth index (table 9). All the other species and biotypes rank below the Prussian carp in linear growth. The interesting peculiarity of stunted colonies of *C. auratus*, *C. gibelio*-1 and *C. gibelio*-2 was the presence of solitary individuals the linear growth and growth rate of which were by several times larger than of other specimens. Such rapidly increasing crucian carps in the selections were not numerous and they were represented by females only. The number of rapidly increasing specimens in every researched water body was different; probably, it depends on productive capabilities of the aquatic areas. Apparently, uneven fish growth in a water body also depends on embryonic development's conditions and on external influence during postembryonal stage, it determines the number of stunted and rapidly increasing specimens in this or that population (Kirpichnikov, 1987).

Table 9. Linear growth of females and males from general selections in the context of comparison

Species / Biotype	t	p
C. auratus-carassius ♂ / ♀	3.3	**0.0007**
C. carassius ♂ / ♀	2.1	**0.08**
C. auratus ♂ / ♀	2.3	**0.012**

Note. Veracious values are marked with bold type.

The life time of crucian carps, representing different species and biotypes, does not exceed 12 years (table 3). In this research almost all age groups were discovered in the Crucian carp, *C. carassius*, Chinese crucian carp, *C. auratus*, hybrids of *C. auratus*–*C. carassius* and Prussian carp, *C. gibelio*-1 (few 10 years old specimens were discovered). The biotypes of the Prussian carp, *C. gibelio*-2, *C. gibelio*-3, *C. gibelio*-4, *C. auratus-gibelio*-2, are more rare, apparently, they reach the age of 12 years too, but due to their little number and rarity the oldest specimens were not represented in the researched selections.

It ought to be remarked that the majority of the investigated species and biotypes were discovered in the dystrophic waters. It is proved by the low liner growth index and growth rate and by presence of numerous additional age rings on the fish scales. However, the unfavorable living conditions did not influence the lifetime of species and biotypes (table 3).

Conclusion

The conducted research, devoted to biological peculiarities of different species and biotypes of crucian carps in Ukrainian water bodies, showed that most of the researched zooids had low linear growth index and low growth rate, they are characterized by the early sexual maturation of spawners. It caused overpopulation of the researched water bodies by the small stunted form. All the researched species and biotypes differ by growth rate and linear growth index but there is no difference in the terms of first sexual maturation and life time. In this case the habitat's influence plays a key role in crucian carps' growth but it does not influence their life time. The individual biological peculiarities of particular species and biotypes almost don't show-up in dystrophic waters. The only exception makes hybrid specimens of *C. auratus*–*C. carassius*, which have the "hybrid power" during the first years of life. According to growth index they leave behind other species and biotypes. However, during the subsequent years the growth of hybrid specimens slows down rapidly and they don't differ from other species by the growth rate.

During different years the species and biotypes of crucian carps are characterized by different growth rate. Primarily it depends on the living conditions (availability of good food resources, favorable oxygen regimen and other factors). When the living conditions are stable the growth rate of species and biotypes slows down after the first sexual maturation. Such regularity was discovered in stunted colonies of crucian carps. The rapidly

increasing individuals of the Chinese crucian carp are characterized by the annual gain increase even after the first sexual maturation, which testifies to the fact that in favorable living conditions the sexual maturation does not influence the growth rate decrease.

In stunted crucian colonies it is possible to come across large females. Apparently, their number depends on "feeding ability" of particular water bodies. Such individuals were discovered in all the researched water bodies without exception.

The crucian carps with low linear growth index usually inhabit shallow, well heated water bodies characterized by winter and summer mass fish mortality, poor food resources, low oxygen concentration. In cold winters such water bodies freeze completely and quickly warm-up to extreme temperatures, making favorable environment for generation of cyanobacteria. The unfavorable conditions have negative impact on the linear growth and growth rate of crucian carps. As a result the species and biotypes of crucian carps, which have a great difference in terms of the first sexual maturation and in growth rate in favorable conditions, become sexually mature simultaneously and much earlier than usually. However, even under the influence of the unfavorable living conditions, the slight differences in linear growth index of particular species and biotypes still remain.

The high lability of biological characteristics of crucian carps, representing different species and biotypes, their sensitive response to changes in living conditions provides an opportunity to use these species as biological indicators of water bodies ecological state.

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