INVESTIGATION ON CARP *(CYPRINUS CARPIO L.)* POPULATION FROM "BAIKEL" NUCLEAR TESTING CRATER WATER.

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The carp (or, wild form - "sazan") is an important commercial species of freshwater fish. Its natural water habitat includes the rivers of the Black, Mediterranean, Caspian, and Aral seas and the Asian coast of Pacific Ocean watershed. It has a disjunctive amphiboreal water habitat (Lopatin, 1989). This species has 3 subspecies: European carp (*Cyprinus carpio carpio* (L.), Svetovidov), Aral sazan (*Cyprinus carpio aralensis* Spitschakov) and Amur sazan (*Cyprinus carpio haematopterus* Temminck. et Schlegel) (Mitrofanov et al., 1988; Berg, 1949; Nickolsky, 1971). Domestication of carp is relatively recent comparatively to other animals: breeding started in China in the 5th century BC (Tuzova, 1989; Fridman, 1991)**.** Carp is very important introduced species. This species was introduced to Central Kazakhstan in 1940 in the Nura river watershed (Mitrofanov et al., 1988). The wild and domestic forms were introduced together.

Introduced carp populations are present on the Semipalatinsk nuclear test site, namely in the Lower Shagan lakes, Shagan reservoir; and Baikel crater (Mitrofanov, Matmuratov, 1996; Krainyuk, 1997). Local people fish for carp in all water bodies.

MATERIALS AND METHODS.

Carps from Baikel crater water was catching in September 1997 and June 1998 years. Morphology variability was investigating by standard morphometric (Pravdin, 1966) and statistical (Zhivotovsky,1991) methods. Some other methods are described below.

Phenotypic investigations on fish were conducted according to the methods proposed by Yakovlev et al. (1980). They were based on common meristic parameters such as the number of rays in fins, the number of vertebrae, etc.

The intra-population phenotypic diversity was estimated according to the Zhivotovsky's (1991) method and the estimation of two parameters and h:

for one specific character :

μ represents the general phenotypic diversity of a population:

$$\mu = \left(\sum_{i=1}^{n} \sqrt{p_i} \right)^2$$

correct of μ:

$$s_\mu = \sqrt{\frac{\mu(n-\mu)}{N}}$$

h is an indicator of the "rare phenotypes":

$$h = 1 - \frac{\mu}{n}$$

correct of h:

$$s_h = \sqrt{\frac{h(1-h)}{N}}$$

for all characters:

$$\bar{\mu} = \frac{\sum_{j=1}^{m} \mu_j}{m} \quad \text{and} \quad s_{\bar{\mu}} = \frac{\sqrt{\sum s_\mu^2}}{m}$$

$$\bar{h} = \frac{\sum_{j=1}^{m} h_j}{m} \quad \text{and} \quad s_{\bar{h}} = \frac{\sqrt{\sum s_h^2}}{m}$$

where p - frequency of phenotype

n- number of phenotypes
m- number of characters and
N- number investigated animals

The inter-population diversity was evaluated by Zhivotovsky's criterion r (Zhivotovsky, 1991):

for each character: $$r = \sum_{i=1}^{n} \sqrt{p_i q_i}$$

and, in general, for all characters: $$\bar{r} = \frac{\sum_{j=1}^{m} r_j}{m}$$

p and *q - frequencies of phenotype in evaluating population; m- general number of characters.*

Two indexes of fish fertility were considered (Nickolsky, 1974; Spanovskaya & Grigorash, 1976): absolute individual fertility (AIF), and relative individual fertility (RIF)
AIF is determined by counting the eggs in a fraction of the ovaries and extrapolation to the total of the ovaries: AIF= (n × G)/ m
Where *n* - number of eggs in a fraction of the ovaries
m - fresh weight of the fraction of the ovaries considered (g)
G - total fresh weight of the ovaries (g).
RIF is the ratio of AIF to female body fresh weight (M): RIF= AIF/M, or to female body length (L in cm): RIF(L)= AIF/L
The state of fish nourishment may be estimated in two way's (Nickolsky, 1974)**:**

by Fulton: $$Q_F = \frac{M_b \cdot 100}{L^3}$$ and

by Clarck: $$Q_c = \frac{M_c \cdot 100}{L^3}$$
Where:
Mb - body mass, g., *Mc* - carcass mass, g., *L* - body length, cm.

The frequency of micronuclei is observed in peripheral blood erythrocytes. The blood is punctioned from the animal's heart and one drop, diluted in a KCl solution (0.9 % for fish, amphibians and reptiles; 0.56 %, for mammals), is spread out on a microscope slide. The smear is air dried and fixed by bathing in methanol for 5 to 10 min. Then, the slide is covered for 3 min with May-Granwald's solution and rinsed for 1 min with distillated water. The preparation is stained with a 2 % Giemsa's solution for 15-20 min. (Ilyinskikh et al., 1992).

The micronuclei are counted under microscope (magnification: ×90). The micronuclei are identified according to the following criteria: they are round shaped structure with a diameter of 4 to 6 µm and must be surrounded by a membrane. Two thousand erythrocytes are considered for each animal. Statistical differences between groups are evaluated by Student's t-test.

RESULTS AND DISCUSSION.

Morphology peculiarities of carp from Baikel crater

The carp population of Baikel was compared with the Toksumak lake population used as the control because this species was not present in the Balyktykol lake. The morphological characteristics of Baikel and Toksumak carps are presented in table 1 (body proportions) and table 2 (meristic characters). Previously published data concerning carp populations from the Shagan (Krainyuk, 1996; 1997**)** and Karasay reservoir (Krainyuk, Fesenko, 1996) are also presented for comparison. Shagan reservoir is located on the Polygon territory near "Atomic lake". Karasay reservoir is located in a non-contaminated area, far away from the Polygon (Tengiz distr., Karaganda prov.). The data were compared using the two-tailed Student t-test.

Significant differences between the carp populations from Baikel and Toksumak were evidenced for 8 of the 20 morphometric characters (body proportion relative to the fish length - L) that we considered. The difference observed for relative eye diameter (o/L) is essentially due to the age of the specimens and are not representative of environmental stress. On the contrary, reduced body height proportions (H/L and h/L) indicate a general deterioration of the environmental conditions and has been reported for many fish species under environmental stress (e.g. Berg, 1949), including carp from the strongly salt-water Great Saryoba lake (Krainyuk, 1993**)**. Fins relative proportions (lP/L, lV/L, lA/L and lD/L) were significantly larger for the carp population of Baikel than for the populations from the control lake; this may indicate an adaptive response to fed scarcity and may be tentatively explained by the necessity for the Baikel carp to swim over longer distances in its quest of feed.

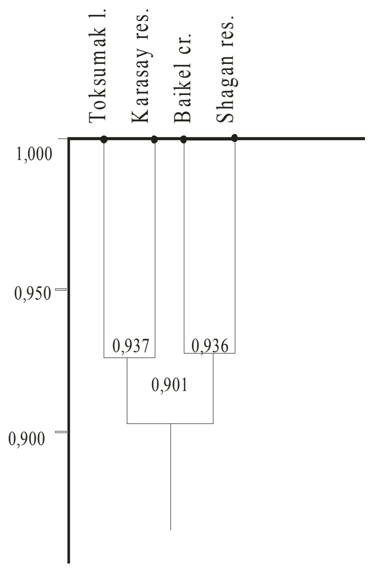

Fig. 1. Relation tree of the carp populations from 4 water reservoirs.

Among the 15 meristic characters considered, 4 were significantly different when comparing the Baikel and Toksumak carp populations. A key feature of the carp population of Baikel, compared to other populations is the high variability of the number of their dorsal, caudal and total vertebrae (d.vert., c.vert., vert.) as shown in table 18 by the high standard deviation (sd). Although the average total number of vertebrae is similar in both populations, their range in Baikel carps is three times that in Toksumak population and the upper limit exceed the maximum number of vertebrae known for *Cyprinus* in general and for this particular species in Kazakhstan (Mitrofanov *et al*., 1988; Berg, 1949; Krainyuk, 1993; 1997). According to Schroder's (1979) ionising radiations has a great influence on the development of the fish backbone system. The higher variability that we observed for Baikel carps might be considered a consequence of morphogenetic and mutagenic processes induced by radiation.

Table 3: Population phenotypical diversity estimators (Zhivotovsky's parameters μ and h) in carp from Central Kazakhstan waters.

	Baikel crater	Toksumak lake	Karasay reservoir	Shagan reservoir
$\mu \pm s\mu$	3.24 ± 0.09	2.14 ± 0.08	2.69 ± 0.08	2.42 ± 0.06
h ± sh	0.12 ± 0.02	0.07 ± 0.02	0.11 ± 0.02	0.07 ± 0.02

A comparison of the carp populations phenotypes of Baikel and Toksumak lakes (this study) and Shagan ("Atomic lake") and Karasay reservoirs **(**Krainyuk & Fesenko, 1995; Krainyuk, 1997) has been carried on using the Zhivotovsky correlation criterion r (Zhivotovsky, 1979) and construction of a hierarchy tree (Farris, 1972). The results (fig. 1) show two distinct clusters: the first one groups the carp populations from the Toksumak lake and Karasay reservoir (the two control sites) while the second one associates the fish populations from Baikel crater and Shagan reservoir (the two radiocontaminated sites). To our knowledge, a common origin of the populations belonging to the same group may not be invoked; we assume that irradiation might have led to an epigenetic selection.

However the influence of external factors other than radiation (e.g. food availability) can not be excluded. The number of rays in fins nor of the number of gills are highly variable parameters of

Table 1. The morphologic parameters of carp from Central Kazakhstan waters

Morphometric characters	Baikel crater (1) (n= 26)			Toksumak lake (control) (2) (n=12)			P * (1) - (2	other populations	
								Shagan a	Karasay b
	Range	M ± se	sd	Range	M ± se	sd		M ± se	M ± se
Body length (L) (cm)	5.4 - 24.5	14.62 ± 0.92	4.71	14.3 - 22.0	18.87 ± 0.67	2.32		20.44 ± 1.22	39.78 ± 0.68
Maximum body height (H/L) (%)	26.42 - 35.78	31.11 ± 0.41	2.11	35.52 - 40.52	37.53 ± 0.46	1.59	0.000 ***	31.06 ± 0.81	32.98 ± 0.24
Minimum body height (h/L) (%)	10.19 - 13.33	11.50 ± 0.18	0.94	11.41 - 14.93	13.36 ± 0.26	0.89	0.000 ***	11.92 ± 0.20	13.27 ± 0.10
Head length (c/L) (%)	28.49 - 35.78	30.98 ± 0.34	1.74	27.33 - 33.57	29.97 ± 0.55	1.91	0.115 ns	27.26 ± 0.32	24.73 ± 0.16
Rostrum's length (r/L) (%)	9.23 - 14.74	10.97 ± 0.23	1.18	9.95 - 13.11	11.18 ± 0.31	1.06	0.602 ns	9.49 ± 0.29	9.18 ± 0.12
Eye diameter (o/L) (%)	4.49 - 9.62	6.52 ± 0.26	1.35	3.62 - 5.88	4.72 ± 0.23	0.79	0.000 ***	4.78 ± 0.21	3.48 ± 0.09
Operculum's length (op/L) (%)	12.58 - 18.35	14.30 ± 0.22	1.12	13.57 - 17.65	14.87 ± 0.32	1.11	0.152 ns	12.70 ± 0.20	13.40 ± 0.12
Forehead width (io/L) (%)	8.85 -13.76	10.49 ± 0.20	1.00	11.56 - 13.99	12.46 ± 0.21	0.72	0.000 ***	10.16 ± 0.13	10.19 ± 0.15
Maximum head height (hc/L) (%)	20.75 - 29.36	23.33 ± 0.34	1.74	21.82 - 27.17	24.07 ± 0.48	1.67	0.225 ns	22.71 ± 0.44	19.29 ± 0.29
Ante-dorsal length (aD/L) (%)	44.90 - 60.00	51.54 ± 0.72	3.66	50.27 - 53.59	51.80 ± 0.33	1.13	0.812 ns	46.95 ± 0.38	47.92 ± 0.71
Post-dorsal length (pD/L) (%)	13.85 - 25.51	18.76 ± 0.49	2.51	16.18 -19.61	17.77 ± 0.35	1.20	0.204 ns	20.10 ± 0.42	19.35 ± 0.24
Pectro-ventral length (P-V/L) (%)	18.52 - 24.80	22.52 ± 0.30	1.53	20.00 - 23.08	21.82 ± 0.24	0.84	0.148 ns	24.57 ± 0.38	23.99 ± 0.17
Ventro-anal length (V-A/L) (%)	24.07 - 30.52	27.11 ± 0.33	1.70	25.58 - 31.37	28.15 ± 0.48	1.65	0.085 ns	27.95 ± 0.36	28.31 ± 0.29
Length of "tail steam" (pl/L) (%)	11.11 - 22.02	15.71 ± 0.47	2.41	14.45 - 18.30	16.17 ± 0.32	1.11	0.534 ns	18.19 ± 0.30	18.25 ± 0.22
Maximum pectoral fin length (lP/L) (%)	19.54 - 26.61	21.96 ± 0.31	1.60	17.39 - 19.89	19.03 ± 0.22	0.76	0.000 ***	18.87 ± 0.53	19.58 ± 0.20
Maximum ventral fin length (lV/L) (%)	17.44 - 22.94	19.13 ± 0.29	1.47	15.30 - 19.46	17.54 ± 0.35	1.21	0.002 **	17.42 ± 0.26	17.72 ± 0.16
Anal fin height (hA/L) (%)	12.96 - 21.10	16.17 ± 0.32	1.62	13.18 - 17.65	15.76 ± 0.65	2.25	0.526 ns	15.09 ± 0.19	14.59 ± 0.20
Dorsal fin height (hD/L) (%)	12.72 - 20.18	15.29 ± 0.35	1.74	10.87 - 16.08	14.48 ± 0.41	1.44	0.169 ns	13.51 ± 0.21	14.05 ± 0.23
Anal fin basis length (lA/L) (%)	6.40 - 11.11	8.25 ± 0.23	1.15	7.04 - 11.89	9.33 ± 0.42	1.45	0.018 *	9.10 ± 0.19	8.27 ± 0.17
Dorsal fin basis length (lD/L) (%)	28.32 - 40.37	34.55 ± 0.47	2.41	36.36 - 39.22	37.88 ± 0.30	1.04	0.000 ***	36.81 ± 0.52	38.64 ± 0.38
Whiskers length (b/L) (%)	3.47 - 9.18	6.23 ± 0.24	1.20	4.65 - 6.82	5.54 ± 0.20	0.70	0.073 ns	5.08 ± 0.14	5.44 ± 0.10

* Probability (two-tailed t-test) ; a Krainyuk (1996; 1997) ; b Krainyuk & Fesenko (1996).

Table 2. The meristic parameters of carp from Central Kazakhstan waters

Meristic characters	Baikel crater (1) (n= 26)			Toksumak lake (control) (2) (n=12)			P * (1) - (2)	other populations Shagan a (n=25)	other populations Karasay b (n=12)
	Range	M ± se	sd	Range	M ± se	sd		M ± se	M ± se
Hard ray's in anal fin (rAh)	3 - 4	3.04 ± 0.04	0.20	3	3.00		1.000 ns	3.00	3.00
Soft ray's in anal fin (rAs)	4 - 6	5.31 ± 0.12	0.62	5 - 7	5.58 ± 0.19	0.67	0.232 ns	5.33 ± 0.19	5.04 ± 0.07
Hard ray's in dorsal fin (rDh)	3 - 4	3.77 ± 0.08	0.43	3 - 4	3.50 ± 0.11	0.37	0.069 ns	3.25 ± 0.13	3.28 ± 0.09
Soft ray's in dorsal fin (rDs)	15 - 20	17.65 ± 0.25	1.29	18 - 21	19.75 ± 0.25	0.87	0.000 ***	18.50 ± 0.19	19.84 ± 0.25
Hard ray's in pectoral fin (rPh)	1	1.00		1	1.00		1.000 ns	1.00	1.00
Soft ray's in pectoral fin (rPs)	12 - 18	15.27 ± 0.25	1.40	15 - 18	16.09 ± 0.28	0.94	0.074 ns	14.33 ± 0.63	15.52 ± 0.28
Hard ray's in ventral fin (rVh)	1	1.00		1	1.00			1.00	1.00
Soft ray's in ventral fin (rVs)	7 - 10	7.96 ± 0.13	0.66	7 - 9	8.00 ± 0.13	0.45	0.850 ns	7.67 ± 0.14	8.00 ± 0.08
Gillraker's number (sp. br.)	21 - 29	24.81 ± 0.36	1.81	20 - 25	22.50 ± 0.45	1.57	0.001 ***	23.58 ± 0.50	23.12 ± 0.33
Scales nb. in *linea laterale* (side line) (squ in l.l.)	34 - 38	36.77 ± 0.22	1.14	36 - 39	37.55 ± 0.31	1.04	0.052 ns	36.75 ± 0.33	38.00 ± 0.19
Scales nb. above *linea laterale* (squ super l.l.)	5 - 7	5.77 ± 0.10	0.51	6	6.00	0	0.205 ns	5.58 ± 0.15	5.86 ± 0.10
Scales nb. under *linea laterale* (squ sub l.l.)	5 - 6	5.54 ± 0.10	0.51	5 - 6	5.80 ± 0.21	0.66	0.192 ns	5.67 ± 0.14	5.82 ± 0.08
Total vertebra nb. (vert.)	29 - 40	34.81 ± 0.44	2.26	33 - 36	34.33 ± 0.42	1.03	0.489 ns	35.92 ± 0.54	35.72 ± 0.29
Dorsal vertebra nb. (d.vert.)	16 - 23	19.31 ± 0.26	1.32	17 - 18	17.60 ± 0.24	0.55	0.000 ***	20.33 ± 0.43	19.28 ± 0.28
Caudal vertebra nb. (c.vert.)	13 - 18	15.50 ± 0.24	1.21	16 - 18	16.80 ± 0.37	0.84	0.002 **	15.58 ± 0.26	16.44 ± 0.19

* Probability (two-tailed t-test) ; a Krainyuk (1996; 1997) ; b Krainyuk & Fesenko (1996).

As a rule, the Baikel carp population is less homogeneous the other ones as attested by a higher variability (standard deviation) of many morphometric and meristic characters and by the Zhyvotovsky's indicators of the population phenotypical diversity μ and h (tabl. 3).

Reproduction

Wild carps belong to a category of fish with polycyclic spawning (Mitrofanov *et al*., 1998- p. 249). For Kazakh water bodies, carps have 2-3 (rarely 1 or 4) spawning cycles per year (Nickolsky, 1940; Taronova, 1956; Goryunova, 1959; Ivanova, 1961; Fedotova, 1970; Ivanov, 1971; Mitrofanov *et al*., 1975; 1988). Typically, carps from Toksumak and other Central Kazakhstan water bodies have three spawning cycles per year. Our observations about the carp population of the Baikel crater indicate a single yearly spawning. In the Baikel crater, in contrast to the common situation, smaller females spawn later than bigger ones, leading to a long-lasting breeding season. Males were indeed active during the whole duration of our observation (from second half of June until the first half of July). Probably, spawning took place from the beginning of June until the end of July. Baikel carp spawn later in the season than carp from other Central Kazakhstan water bodies where most of the reproduction activity is completed about the first week of June. In our opinion, long-lasting spawning in Baikel crater is connected with the shortage of water vegetation on which the female fish will lay down the roe.

Table 4. Comparison of fertility levels of carp in Kazakhstan waters.

Water bodies	Body size (cm)	Absolute individual fertility (103 eggs/ind.)	Individual fertility relative to the mass (103 eggs g□1)	Individual fertility relative to the size (103 eggs cm□1)	References
Baikel crater	12.5	1.7	44.7	15.5	This study
	16.9	6.1	51.8	26.12	
	22.9	13.2	58.5	29.7	
canal Irtysh-Karaganda	--	121.0	--		Abbakumov (1977)
Ili river delta and salt lakes	25- 29	29.83	--	1029-1193	Mitrofanov *et al*. (1975)
	29- 37	114.4	--	3092-3945	
	37- 45	170.5	--	3789-4608	

Carp in Central Kazakhstan reaches puberty between their 3rd to 7th year, when their body length exceeds 16 cm (Mitrofanov et al., 1975; 1988; Kuznetzova, 1975; Taronova, 1956; Fedotova, 1973). Exceptionally, due to poor water quality and feed shortage, carp in some water bodies reach puberty while the body length is less than 15 cm (Mitrofanov et al., 1988). For the Baikel population, puberty is already acquired females in their 3rd year with about 12.5 cm body length and 38 g body mass (Krainyuk, 1997) and the reproductive function in the Baikel crater is essentially the fact of 15 to 17 cm individuals. The sex ratio amounts to a 1:1.4 ratio in favour of females.

Fertility of carp from Baikel crater is low (table 4). The average fertility of the biggest females is more than twice lower than that of females of similar size from for another water body also characterised by poor environmental conditions like the Ili river delta or salt lakes (Mitrofanov et al., 1975).

We believe that the low absolute individual fertility is caused by food scarcity which acts not only on fish growth but has an even stronger effect of the fertility. Earlier puberty associated with an unusual small body size is an adaptive response of the fish population to environmental stress, including irradiation. However it is mainly ruled by feed scarcity. Another anomaly identified was lipid resorption in the ovaries long before the end of spawning.

This anomaly was also described for Shagan reservoir carps (Krainyuk, 1997**)**. We assume that, in both cases, this phenomenon is induced by the lack of spawning areas and other negative environmental factors. Asymmetry of functionally active male gonads was observed in Baikel carps

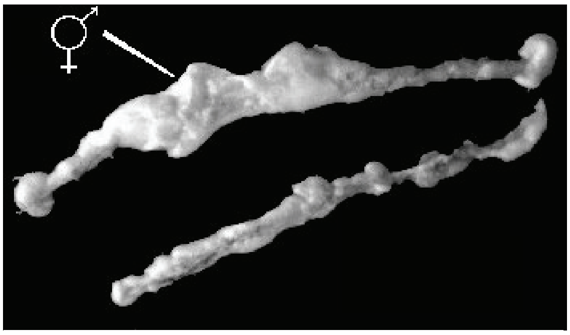

Fig. 2. Gonad of an hermaphrodite specimen caught in the Baikel crater.

but is often found in many carp populations from Central Kazakhstan; and can not be considered as a indicator of abnormal fertility.

If the fertility reduction in carp from the Baikel crater can not undoubtedly related to radiations, the presence of one hermaphrodite individual among the carp specimens sampled in the population of the Baikel crater brings another argument in favour of this hypothesis. Such a phenotype is indeed extremely rare; this hermaphrodite specimen catch in the Baikel crater is the only one encountered in 10 years of investigation on carp populations in Central Kazakhstan. Hermaphroditism, which is a normal phenomenon and the rule in some fish species (Nickolsky, 1965; Kirpichnikov, 1987; Fishelson, 1970; Young & Martin, 1982), constitutes a violation of normal ontogenesis in carp and other species including minnows, guppy and *Tilapia* (Nickolsky, 1965; Kirpichnikov 1987; Bullough, 1940; Kossmann, 1971; Rothbard et al., 1989**)**. The gonads of this hermaphrodite specimen (Fig. 2) appear as a white testicles with the ovaries in central area; ovocytes were in the phase of lipids resorption. Testicles were functionally inactive and presented a hard consistency in contradiction to the normal consistency of fertile male testis. This specimen had no reproductive ability either as male or female and displayed an "average" phenotype.

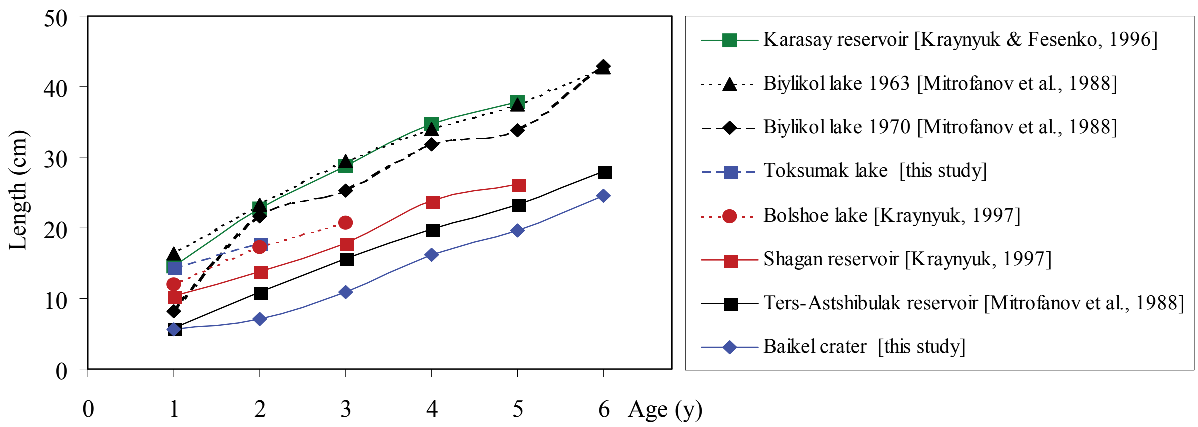

Fig. 3. Growth of carp in Central Kazakhstan waters.

Growth and state of nourishment

Fish growth is a good indicator of the general life conditions of individuals and populations, which combines the influence of biotic and abiotic factors. It integrates the diverse individual and population adaptive responses (genetic, physiologic etc.) to the influence of environmental factors (Vasnetzov, 1947; 1953; Nickolsky, 1958; 1965; 1974; Kirpichnikov, 1987). Figure 3 shows growth data fort carp seven water reservoir, including lake Biylikol (used for carp introduction) and Ters-Astshibulak reservoir (South Kazakhstan) which is known for sustaining minimal growth of carps.

The very low growth rate (similar to that reported for Ters-Astshibulak reservoir) observed for carps from the Baikel crater is essentially due to the oligotrophic character of the water and to subsequent feed shortage. As zoo- and phyto-plankton and benthos are very poor in the water from the crater, external feed sources (plants from the crater banks, seeds, terrestrial insects) contribute significantly to the carp diet in this water body. “Filtering” the air-water interface to ingest floating

Table 5: The state of nourishment of carp population in Central Kazakhstan waters.

Water body, date of observation	coefficient state of nourishment (M ± se)		Reference
	by Fulton	by Clark	
Baikel crater, Sep. 1997	2.17 ± 0.12	--	Krainyuk (1997)
Baikel crater, Jun. 1998	2.46 ± 0.04	2.10 ± 0.05	this study
Shagan reservoir, Jul. 1998	2.64 ± 0.11	2.11 ± 0.07	Krainyuk (1997)
Toksumak lake, Aug. 1998	2.92 ± 0.05	2.49 ± 0.05	this study
Karasay reservoir, Oct.-Nov. 1995	2.56 ± 0.04	--	Krainyuk & Fesenko (1996)

Table 6: Micronuclei frequencies in carp (*Cyprinus carpio*) populations.

	Baikel, 1997 (n = 3; 2000 cells/ind)		Baikel, 1998 (n = 16; 2000 cells/ind)		Toksumak, 1998 (n = 2; 2000 cells/ind)	
	M ± se	sd	M ± se	sd	M ± se	sd
total	0.51 ± 0.05	мар.62	0.17 ± 0.02	0.08	0	0
with 1 mn	0.47 ± 0.04	мар.14	0.15 ± 0.02	0.07	0	0
more 1 mn	0.04 ± 0.003	0.69	0.02 ± 0.01	0.03	0	0

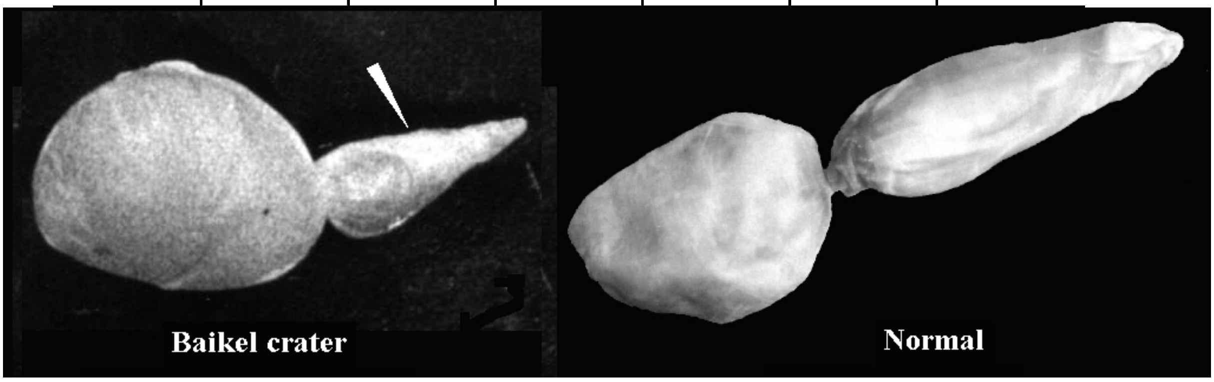

Fig. 4. Swimming bladder of carps from the Baikel crater (left) showing the atrophy of the rear part (arrow) compared to a normally developed swimming bladder (right).

debris constitutes an important feeding pattern of Baikel carps. The state of fish nourishment may be defined by a ratio between their body weight (eviscerated (Clark coefficient) or not (Fulton coefficient)) and their body length. Compared to carps from other water bodies, those from Baikel exhibit a relatively low nourishment coefficient (table 5) confirming the limited feed availability. Considering the two sampling campaigns, we observed a rather large variability of the nourishment coefficients, which ranged from 1.95 to 2.77 (Fulton coefficient) and from 1.93 to 2.55 (Clark coefficient), linked to seasonal variations. A significantly higher (Tst: $\alpha \leq 0.05$) in summer (June) compared to autumn (September) is explained by the increase of the gonad mass during the spawning season.

Anatomical anomalies

One of indicators of effect of radiation, according to experimental data (Schroder, 1979), is the malformation of the swimming bladder structure. We observed an atrophy of back part (arrow) of swimming bladder in 100 % of the carps from a Baikel crater (fig. 4).

Micronuclei analysis

The genomic instability of carp populations has been evaluated on the basis of the frequency of micronuclei occurrence in erythrocytes cells. For each individual, 2000 cells were analysed under microscope. The results demonstrated an excess amount of cells with one or more micronuclei in erythrocytes cells of carps from the Baikel crater as compared to the population from the Toksumak reservoir (table 6).

CONCLUSION

Our research shows in the determination of strong carp populations from the Baikel crater as having suppressing negative environmental conditions. Two basic negative factors exercise influence on this population. The first factor is the increase of the radiation background. Its influence is indicated by the following tests:

1. The increase of Zhivotovsky's population diversity criterion, compared with the control and Shagan reservoir populations. This shows that the evolutionary process has taken place in the Baikel population.

2. The increase of vertebrae number limits show the influence of irradiation on fish genomes (Schroder, 1979).

3. Hermaphrodite fish are found in the Baikel carp population. We connect hermaphroditism with the ionizing irradiation influence. The hermaphrodite specimen were found in some fish species progeny after irradiating in aquarial testing (Schroder, 1979).

4. All carps from the Baikel crater have anomalous swimming bladders (atrophy of rear part). This is in concert with I. Schroder's (1979) data about swimming bladder anatomy changes by ionizing irradiation influences.

5. Micronuclei analysis show an increase of the level of anomalous nuclei in the Baikel carp with "zero" number of anomalies in the control population of carp from Toksumak lake.

The second factor is feeding resources scarcity which may be observed in the Baikel crater hydrobiome. This is shown by the following two tests:

1. Diminished growth of fishes;

2. Decreased state of nourishment.

The Baikel carp population have the worst absolute and relative female fertility for Kazakhstan water bodies. This results from the combined influence of these two factors.

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РЕЗЮМЕ

Крайнюк В. Н., Вандекастиль К. М. **Исследование популяции карпа (Cyprinus carpio L.) из водоема ядерной воронки "Байкель"**

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В статье приводятся материалы исследований популяции карпа из ядерной воронки "Байкель". Описаны основные изменения, вызванные как воздействием ионизирующего излучения, так и других факторов. Для популяции карпа из водоема воронки характерно повышения показателя популяционного разнообразия Животовского, снижение темпов роста, упитанности и плодовитости. Частично это вызвано воздействием радиации, частично- дефицитом кормовых ресурсов, а так же совместным влиянием обоих факторов. Кроме того, в исследованной популяции карпа была обнаружена одна гермафродитная особь, что мы непосредственно связываем с последствиями хронического облучения. Этим же, по нашему мнению объясняется и тот факт, что все особи имели аномалию плавательного пузыря- атрофию задней капсулы. Морфологически байкельские карпы особо выделялись размахом изменчивости количества позвонков: от 29 до 40, что согласуется с материалами I.H. Schroder (1979) по влиянию ионизирующего излучения на морфологию и анатомию рыб.