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RESEARCH ON THE EVOLUTION OF MORPHOLOGICAL INDICES IN THE *Cyprinus carpio*- SPECIES DURING THE COLD SEASON IN THE CONTEXT OF CLIMATE CHANGE

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Abstract

Due to the increasingly warm winters of the last 20 years, the wintering of cultured carp is achieved with increasing numerical and weight losses. Water temperatures during the winter period reach 10-12°C, temperatures that intensify the metabolism and set the fish material in motion. Because these temperatures are for short periods, no natural food grows in the water. The paper presents the results of the research carried out in the cold seasons of 2020-2021, 2021-2022, and 2022-2023 on cultured carp aged two summers, from the Research and Development Station for Fisheries Nucet. Wintering was done in earthen ponds, in two variants: variant V1 - without feed distribution and variant V2 - with feed distribution. In view of this study, somatic measurements were carried out, both in autumn and in spring, to assess the change in the values of the condition coefficient, survival percentages, as well as the decrease in weight and number, during the cold season period, in the context of climate change.

Key words: *carp, global climate, morphological indices, temperature.*

INTRODUCTION

Aquaculture continues to significantly expand its production, making it the fastest-growing food production sector globally. Freshwater ecosystems are strongly threatened by climate change. In the context of climate change, phenotypic plasticity takes on particular relevance, as this process allows organisms to cope with the unpredictability of environmental stressors over time (Chang et al., 2021; Costache et al., 2021; Popa et al., 2022). The common carp *Cyprinus carpio* (Linnaeus, 1758) is one of the most widely-distributed freshwater fishes in the world (Cocan & Mireșan, 2018; Anin et al., 2021). In the technological process of carp farming, in fish farms that use earth ponds, for the cold period of the year, the fish is stored at a high density, in special wintering earth ponds. The temperature of technological water influences: the oxygen content of the water, the amount of oxygen assimilated by aquatic organisms, the availability of food, including metabolic activity (Dobrotă, 2022). In these situations, the growth rate of fish is influenced in direct proportion to water temperature, which in turn is correlated with latitude (Hokanson, 1977). Temperature plays a critical role in the growth and development of aquatic animals (Ngoan, 2018). Fish, being poikilothermic, may particularly be sensitive to temperature variations resulting from climate change (Sae-Lim et al., 2017; Adhikari et al., 2018). Metabolism and physiology, as well as feeding behavior and growth performance of most finfish species are likely to be affected (Marcogliese, 2008; Lemasson et al., 2018; Anin et al., 2023).

During the winter period, when the fish does not feed, the organism consumes its own reserves to cover the energy needs. First of all, the hydrocarbons are exhausted, but they are consumed quickly, then the fatty substances follow, and only after they are exhausted, the proteins are broken down. The intense and long-term consumption of protein substances leads to the death of the body. It was found that the accumulation of adequate fat reserves in the carp's body ensures its good wintering, influencing both weight loss and survival (Gheracopol, 1971; Dobrotă, 2008).The dynamics in the fat content of fish is especially under the influence of quantity and quality of food (Oprea & Georgescu, 2000). As the water temperature drops below 10º C, the cultured carp's behavior changes becoming less less active, and when the temperature value approaches 1º C they are inactive (hibernate) and a series of changes in metabolism occur. The purpose of the research was to highlight the correlation between environmental factors and fish food consumption during the cold season and implicitly their increase or decrease in weight. The method of capitalizing the additional feed administered to the fish and the amount of feed consumed was followed depending on the oscillating value of the temperature and concentrations of dissolved oxygen in the water.

The condition factor or Fulton coefficient is an index studied by specialists as being very valuable for the indications it can give them in terms of how carp overcome the winter period (Latiu et al., 2022; Savin et al., 2022; Thangaraji et al., 2023).

MATERIALS AND METHODS

During the periods October 2020-March 2021, October 2021-March 2022 and October 2022-March 2023, the experimental works were carried out at the Research and Development Station for Fisheries Nucet (RDSF Nucet). The experimental base is located in the main bed of the Ilfov stream, downstream of the Ilfoveni reservoir. The experimental ponds (B1, B2, B3, B4, B5 and B6) with the surface of 1000 m^2/pond and the depth between 1.5-2.4 m, were used for the wintering of the experimental biological material. The stocking of two-summer old carp for wintering was realized between October 10 and 25. The average weight of the biological material was between 557-621 g/ex, being stocked in ponds with an area of 1000 m^2, in monoculture. During the warm season, wintering ponds were left to dry and disinfected with lime chloride, more intensively in wet areas. The water supply was made from a common supply channel, through supply monks, where was installed a metal screen with a 4 mm mesh, to prevent the entry of wild fish species. Since the supply channel was common, we can state that, in all 6 experimental ponds, the physico-chemical characteristics of the water were identical.

Wintering of carps was done in earthen ponds, equipped with water supply and drainage facilities, in two variants, in triplicate, as follows:

- Variant V1, without feed distribution, in ponds B1, B2 and B3, with a stocking density of 1000 kg/pond (10000 kg/ha);
- Variant V2, with feed distribution (Aller Classic - 3 mm) was administered in ponds B4, B5 and B6, with a stocking density of 1000 kg/pond (10000 kg/ha).

At the end of each winter season, between March 16 and April 9, the biological material was fished, and the duration of the winter period was 135 ± 2 days.

During the experimental period, the data on the environmental parameters, water quality, food consumption were recorded and interpreted, at the beginning and at the end of the experimental period, biometric measurements were made to determine the morphological indices studied. In order to establish the physico-chemical parameters of water, water samples were collected at intervals of 6-7 days, and their analysis was carried out in the hydrochemistry laboratory of RDSF Nucet, according to the methodology in the specialized literature.

The results obtained in the three years of study, during the winter season, were statistically processed using: Excell (Office 2021), Windows xp and descriptive statistics.

RESULTS AND DISCUSSIONS

During the whole period of the experiments, the hydrochemical parameters of the technological water were monitored and the fresh water supply system of the wintering ponds, as well as the duration of covering the ponds with ice, were monitored. The analysis and interpretation of the results of the water samples was carried out in accordance with the "Regulation on the classification of surface water quality in order to establish the ecological status of water bodies", correlated with the data from the specialized literature for waters used for fish farming (Order no. 161, 2006) (Table 1).

The main factor of importance on the behavior of the carp during the winter period is the water temperature, which led us to follow its

evolution. Air and water temperatures were recorded during the three experimental years in the cold season (2020-2021, 2021-2022 and 2022-2023). Positive air temperatures were recorded in January and February (low quantitative precipitation). The month of March was colder during the night, with temperatures lower than normal for the period, and during the day with precipitation in the form of snow.
In the three experimental winter seasons, the water temperature recorded average values in the range of 2.0 - 9.6°C, and air temperatures of up to 10.5°C were recorded during the day (Table 2). For short periods of time, a transparent ice was formed, with no mortality of fish material recorded.
This highlights the need for a continuous supply of well-oxygenated water to the wintering ponds.

Table 1. The main parameters of technological water recorded for the winter period 2020-2023 (average values)

No. crt.	The chemical parameter		UM	Parameter values		
				Source	Experimental ponds	Optimum according to quality standards
				Average of the years 2020-2023		
1.	pH		pH units	7.2	7.6	7-7.8
2.	Total hardness		(^{0}D)	13.8	14.6	12
3.	Calcium (Ca^{2+})		mg/l	41.6	40.4	90-120
4.	Magnesium (Mg^{2+})		mg/l	38.92	38.76	10-40
5.	Ca^{2+} / Mg^{2+}		mg/l	1.06	1.04	5
6.	Alkalinity		mg/l	154.8	172.8	200-400
7.	Organic substance		mg $KMnO_4$/l	13.84	22.64	20-60
8.	Oxygen		mg/l	3.50	5.72	5-10
9.	Nitrites (NO^-_2)		mg/l	0.0012	0.0024	0.03
10.	Nitrates (NO^-_3)		mg/l	0.026	0.098	2.5-4
11.	Phosphates (PO^{3-}_4)		mg/l	0.016	0.056	0.05-1.5
12.	Ammonia (NH^+_3)		mg/l	lack	lack	lack
13.	Ammonium (NH^+_4)		mg/l	0.008	0.056	0.5-1
14.	Chloride	Cl^-	mg/l	10.60	12.37	30
		Na Cl	mg/l	17.53	20.46	20

Table 2. Average water and air temperatures for the winter period 2020-2023

Month and year	Water temperature			T med. air, ˚C
	T min., ˚C	T max., ˚C	T med., ˚C	
2020-2021 Season				
December 2020	1.8	3.8	2.3	-1.9
January 2021	1.9	3.4	2.0	1.3
February 2021	2.5	5.0	3.6	4.1
March 2021	3.5	13.0	8.7	8.5
2021-2022 Season				
December 2021	2.0	5.0	3.8	5.1
January 2022	1.5	2.5	2.3	0.8
February 2022	2.5	6.5	4.1	5.8
March 2022	5.0	12.5	9.6	10.3
2022-2023 Season				
December 2022	3.5	5.0	4.2	2.4
January 2023	2.0	5.0	3.5	3.1
February 2023	3.0	7.5	4.7	4.4
March 2023	5.0	10.5	7.7	10.5

In variant V2 (with feed distribution), in the three seasons during which the experiments were carried out, food was administered in amount of 1% of the total weight of the stocked biological material, when the water temperature exceeded 10°C, and 0.5% when the temperature was between 6-10°C. No feed was administered below temperature of 6°C. The food was administered at fixed points with the easy possibility of controlling its consumption.

When unconsumed feed was found, no more food was given in the next period until it was consumed. The amount of feed administered in the 2020-2021 winter season was 310 kg, in the 2021-2022 season it was 280 kg, and in the 2022-2023 season it was 320 kg. The feeding was carried out with an extruded granulated feed (Figure 1) - *Aller classic* 3 mm which has the following content: fish meal (15 %), soybean meal (25%), blood meal (10 %), corn (25%), wheat (20%), fish oil (2.5%) and vegetable oils (2.5%). The biochemical characteristics of the feed are as follows: NFE 43.5%, protein 30.0%, ash 7.0%, fat 7.0%, cellulose 5.0%, active urease 0.3%, and as minerals P and N. The feed also contains vitamins: D3, A and E.

Figure 1. Granulated feed *Aller classic* 3 mm

Figure 2. Biological material at stocking in autumn 2020

In the 2020-2021 winter season, the winter stocking were made between 26-30 October 2020, with carp aged two summers (Figure 2), with the following average weights: in the V1 variant 602 g/ex, and in V2 variant 600 g/ex. In the autumn, the stocking of the wintering ponds was carried out respecting the established density (10000 kg/ha), so in both variants, the number of exemplars per pond was found in the range 1623-1704. During the period 04.05-04.09.2021, the spring fishery was conducted with the following results (Table 3, Figure 3):

- the average harvested quantities were: in the V1 variant - 889 kg, and in the V2 variant - 1050 kg;
- the average weights were: in the V1 variant - 573 g/ex, and in the V2 variant - 641 g/ex.;
- survival had lower values in the V1 variant - 89.7% compared to the V2 variant - 98.2%.

Figure 3. Biological material in the spring of 2021

Figure 4. Biological material at stockingin autumn 2021

Figure 5. Biological material in the spring of 2022

In the 2021-2022 winter season, the winter stocking were made between 21-27 October 2021, with carp aged two summers (Figure 4), with the following average weights: in the V1 variant 607 g/ex, and in V2 variant 584 g/ex. In the autumn, the stocking of the wintering ponds was carried out respecting the established density (10000 kg/ha), so in both variants, the number of exemplars per pond was found in the interval 1610 - 1795. In the period 04.04-10.04.2021, the spring fishery was conducted with the following results (Table 4, Figure 5):

- the average harvested quantities were: in the V1 variant-870 kg, and in the V2 variant-1059 kg;
- the average weights were: in the V1 variant-585 g/ex, and in the V2 variant-630 g/ex.;
- survival had lower values in the V1 variant-90.3% variant compared to the V2 variant-98.2% .

In the 2022-2023 winter season, the winter stocking were made between 24-28 October 2022, with carp aged two summers (Figure 6), with the following average weights: in the V1 variant 611 g/ex, and in V2 variant 604 g/ex.

Table 3.The results obtained for the two experimental variants in the winter season 2020-2021

Recorded parameters		Variant V1 (without feed distribution)			VariantV2 (with feed distribution)			V1	V2
Pond		B1	B2	B3	B4	B5	B6	Average	Average
Stocking in the fall	Quantity (kg)	1000	1000	1000	1000	1000	1000	1000	1000
	W average (g/ex)	592	602	613	587	597	616	602	600
	No. specimens	1689	1661	1631	1704	1675	1623	1661	1667
	Ex/ha	16892	16611	16313	17036	16750	16234	16605	16673
	Kg/ha	10000	10000	10000	10000	10000	10000	10000	10000
	Fulton coefficient	3.73	3.62	3.58	3.61	3.59	3.57	3.64	3.59
Spring fishing	Sv (%)	89.8	89.6	89.8	98.1	97.9	98.6	89.7	98.2
	Quantity (kg)	856	859	847	1045	1046	1058	854	1050
	W average (g/ex)	564	577	578	625	638	661	573	641
	No. specimens	1517	1488	1465	1671	1640	1601	1490	1637
	Ex/ha	15169	14884	14649	16712	16399	16006	14901	16372
	Kg/ha	8555	8588	8467	10445	10462	10580	8537	10496
	Fulton coefficient	2.82	2.8	2.78	3.46	3.45	3.46	2.8	3.46

Table 4. The results obtained for the two experimental variants in the 2021-2022 winter season

Recorded parameters		V1 Variant (without feed distribution)			V2Variant (with feed distribution)			V1	V2
Pond		B1	B2	B3	B4	B5	B6	Average	Average
Stocking in the fall	Quantity (kg)	1000	1000	1000	1000	1000	1000	1000	1000
	W average (g/ex)	588	621	612	557	592	603	607	584
	No. specimens	1701	1610	1634	1795	1689	1658	1648	1714
	Ex/ha	17007	16103	16340	17953	16892	16584	16483	17143
	Kg/ha	10000	10000	10000	10000	10000	10000	10000	10000
	Fulton coefficient	3.61	3.59	3.62	3.58	3.6	3.6	3.61	3.59
Spring fishing	Sv (%)	91.4	89.3	90.2	97.8	98.5	98.3	90.3	98.2
	Quantity (kg)	881	866	864	1059	1058	1061	870	1059
	W average (g/ex)	567	602	586	603	636	651	585	630
	No. specimens	1554	1438	1474	1756	1664	1630	1489	1683
	Ex/ha	15544	14380	14739	17558	16639	16302	14888	16833
	Kg/ha	8814	8657	8637	10588	10582	10612	8702	10594
	Fulton coefficient	2.91	2.87	3.01	3.51	3.59	3.53	2.93	3.54

In the autumn, the stocking of the wintering ponds was carried out respecting the established density (10000 kg/ha), so in both variants, the number of specimens per pond was included in the interval 1608 - 1686. In the period 04.03-04.07.2023, the spring fishery was conducted with the following results (Table 5, Figure 7):

- the average harvested quantities were: in the V1 variant - 855 kg, and in the V2 variant - 1049 kg;
- the average weights were: in the V1 variant-580 g/ex, and in the V2 variant - 644 g/ex.;
- survival had lower values in the V1variant - 90.1% compared to the V2 variant - 98.4%.

Figure 6. Biological material at stocking in autumn 2022

Figure 7. Biological material in the spring of 2023

Table 5. The results obtained for the two experimental variants in the 2022-2023 winter season

Recorded parameters		V1 Variant (without feed distribution)			V2 Variant (with feed distribution)			V1	V2
Pond		B1	B2	B3	B4	B5	B6	Average	Average
Stocking in the fall	Quantity (kg)	1000	1000	1000	1000	1000	1000	1000	1000
	W average (g/ex)	611	601	622	593	608	612	611	604
	No. specimens	1637	1664	1608	1686	1645	1634	1636	1655
	Ex/ha	16367	16639	16077	16863	16447	16340	16361	16550
	Kg/ha	10000	10000	10000	10000	10000	10000	10000	10000
	Fulton coefficient	3.59	3.64	3.68	3.67	3.57	3.65	3.64	3.63
Spring fishing	Sv (%)	90.2	90.6	89.4	98.1	98.4	98.6	90.1	98.4
	Quantity (kg)	853	861	851	1052	1047	1047	855	1049
	W average (g/ex)	578	571	592	636	647	650	580	644
	No. specimens	1476	1507	1437	1654	1618	1611	1474	1628
	Ex/ha	14763	15075	14373	16543	16184	16111	14737	16279
	Kg/ha	8533	8608	8509	10521	10471	10472	8550	10488
	Fulton coefficient	2.83	2.96	3.02	3.61	3.49	3.55	2.94	3.55

The weight losses and the increase in growth (g) per season and experimental variants are presented in Figure 8.

Figure 8. Weight loss and growth factor over years and experimental variants

In the season 2020-2021, the experimental variant V1 (without feed distribution), decreases in the average individual weight were recorded in all three experimental ponds. The physiological losses for each pond were: B1- 25 g/ex; B2- 25 g/ex; B3- 35 g/ex. In the experimental variant V2 (with feed distribution) increases in the average individual weight were recorded in all three experimental ponds. The increases recorded for each pond were: B4- 38 g/ex; B5- 41 g/ex; B6- 45 g/ex.

In the season 2021-2022, the experimental variant V1 (without feed distribution), decreases in the average individual weight were recorded in all three experimental ponds. The physiological losses for each pond were: B1- 21 g/ex; B2- 19 g/ex; B3- 26 g/ex. In the experimental variant V2 (with feed distribution) increases in the average individual weight were recorded in all three experimental ponds. The increases recorded for each pond were: B4- 46 g/ex; B5- 44 g/ex; B6- 48 g/ex.

In the season 2022-2023, the experimental variant V1 (without feed distribution), decreases in the average individual weight were recorded in all three experimental ponds. Physiological losses for each pond were: B1- 33 g/ex; B2- 30 g/ex; B3- 30 g/ex. In the experimental variant V2 (with feed distribution) increases in the average individual weight were recorded in all three experimental ponds. The increases recorded for each pond were: B4- 43 g/ex; B5- 39 g/ex; B6- 38 g/ex.

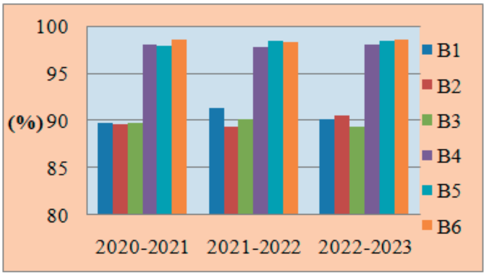

Figure 9. The percentage of survival variation in the three years of study in experimental ponds

In the three years of the study, on experimental variants, the survival rate (Sv %) were between 89.3% and 98.6% (Figure 9).

In the 2020-2021 season, in the V1 variant (without feed distribution) the survival percentage was in the range of 89.6-89.8%. The lowest percentage was recorded in pond B2, where Sv=89.6%, and in the other two ponds (B1 and B3) identical survivals of 89.8% were recorded. In the V2 variant (with feed distribution) the survival recorded values between 97.9-98.6%, the highest survival being recorded in the B6 pond of 98.6%, the lowest being recorded in the B5 pond of 97.9% and in pond B4 a survival rate of 98.1% was recorded.

In the 2021-2022 season, in the V1 variant (without feed distribution) the survival percentage was in the range of 89.3-91.4%. The lowest percentage was recorded in pond B2, where Sv=89.3%, the highest was recorded in pond B1, where Sv=91.4%, and in pond B3 Sv=90.2% was recorded. In the V2 variant (with feed distribution) the survival recorded values between 97.8-98.5%, the highest survival being recorded in the B5 pond of 98.5%, the lowest being recorded in the B4 pond of 97.8% and in pond B6 a survival rate of 98.3% was recorded.

In the 2022-2023 season, in the V1 variant (without feed distribution) the survival percentage was in the range of 89.4-90.6%. The lowest percentage was recorded in pond B3, where Sv=89.4%, the highest was recorded in pond B2, where Sv=90.6%, and in pond B1 Sv= 90.2% was recorded. In the V2 variant (with feed distribution) the survival recorded values between 98.1-98.6%, the highest survival being registered in the B6 pond of 98.6%, the lowest being recorded in the B4 pond of 98.1% and in pond B5 a survival rate of 98.4% was recorded.

In all the years of study, at stocking, in both experimental variants, the Fulton coefficient had close values, being in the range of 3.57 - 3.73.

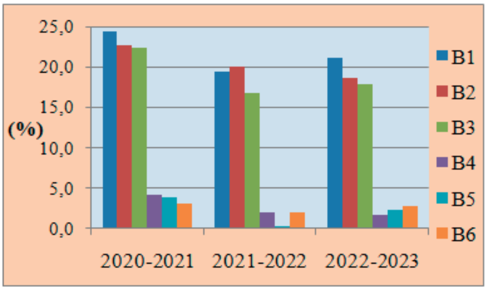

Figure 10. Reduction of the Fulton coefficient in percent (%) during the cold season by years and experimental ponds

The reduction of Fulton coefficient by years and experimental variants was between 16.9% and 24.4% for V1, respectively 0.3% to 4.2% for V2 (Figure 10).

In the 2020-2021 season, for spring fishing in the V1 variant (without feed distribution), a sharp decrease in this coefficient was observed, the lowest value being recorded in the B3 pond of 22.3%, the highest value being recorded in the B1 pond of 24.4% and in the B2 pond the value of 22.7% was recorded. In the V2 variant (with feed distribution) a slow decrease of this coefficient was observed, its lowest value being recorded in the B6 pond of 3.1%, the highest value in the B4 pond of 4.2%, and in the B5 pond there was a decrease in the Fulton coefficient of 3.9%.

In the 2021-2022 season, for spring fishing in the V1 variant (without feed distribution), a sharp decrease in this coefficient was observed, the lowest value being recorded in the B3 pond of 16.9%, the highest value being recorded in the B2 pond of 20.1% and in the B1 pond the value of 19.4% was recorded. In the V2 variant (with feed distribution), a slow decrease of this coefficient was observed, its lowest value being recorded in the B5 pond of 0.3%, the highest value in the B4 pond of 2.0%, and in the B6 pond there was a decrease in the Fulton coefficient of 1.9%;

In the 2022-2023 season in spring fishing in the V1 variant (without feed distribution), a sharp decrease in this coefficient was observed, the lowest value being recorded in the B3 pond of 17.9%, the highest value being recorded in the B1 pond of 21.2% and in the B2 pond the value of 18.7% was recorded. In the V2 variant (with feed distribution) a slow decrease of this coefficient was observed, its lowest value being recorded in the B4 pond of 1.6%, the highest value in the B6 pond of 2.7%, and in the B5 pond there was a decrease in the Fulton coefficient of 2.2%.

CONCLUSIONS

The survival rate of the two summers carp, during the cold season, in the V2 variant was clearly superior to the V1 variant, in all ponds in all three years of the study, as follows: in the V1 variant it fell within the range of 89.3-91, 4%, compared to the V2 variant where it fell within the range of 97.8-98.6%. Thus, it was concluded that if the carp of two summers is fed in the cold season, the numerical losses are reduced.

From the point of view of weight loss, in the V1 variant it was found that they had values that fell within the range of 19-35 g/ex. In the case of variant V2, an increase in the average weight is found in all the years of the study in all ponds, with values between 38-48 g/ex.

In the case of the Fulton coefficient, in the V1 variant, a sharp decrease was found, ranging from 16.9% to 24.4%, compared to the V2 variant, where it had a slight decrease, ranging from 0.3% to 4.2%.

In conclusion, as much as the temperature allows, feeding the carp during the cold season reduces the numerical losses and causes an increase in the individual weight, obtaining a vigorous stocking material in the spring. Numerical and quantitative losses are minimal.

REFERENCES

Adhikari, S., Keshav, C. A., Barlaya, G., Rathod, R., Mandal, R. N., Ikmail, S., Saha, G. S., De, H. K., Sivaraman, I., Mahapatra, A. S., Sarkar, S., Routray, P., Bindu, R., & Sundaray, J. K. (2018). Adaptation and Mitigation Strategies of Climate Change Impact in Freshwater Aquaculture in some states of India. *Journal of Fisheries Science, 12*(1), 16–21.

Anin, I. A., Radu, D., Hassan, A. A. M., Maftei, M., Costaiche, G., & Nicolae, C. G. (2023). The efficiency of carp growing in floating cages through raring and lotting. *AgroLife Scientific Journal*, *12*(1), 9-14.

Anin, I. A., Pogurschi, E. N., Marin, I., Popa, D., Vidu, L., & Nicolae, C. G. (2021). The influence of the density of juvenile carp raised in floating cages on the conversion efficiency of feed. *Scientific Papers. Series D. Animal Science, LXIV*(1), 503-508.

Chang, C. Y., Bräutigam, K., Hüner, N. P. A., & Ensminger, I. (2021). Champions of winter survival: cold acclimation and molecular regulation of cold hardiness in evergreen conifers. *The New phytologist, 229*(2), 675–691.

Cocan, D., & Mireșan, V. (2018). *Ichthyology, Vol. I, Systematics and Morphology of Fishes*. Cluj-Napoca, RO: Colorama Publishing House.

Costache, M., Costache, M., Marica, N., Radu, D., & Nicolae, C.G. (2021). Growth technologies for the complex exploitation of aquatic basins from the traditional fish farms. *Scientific Papers. Series D. Animal Science, LXIV*(2), 423-430.

Dobrotă, N. G., Costache, M., Stăncioiu, S., & Dobrotă, G. (2008). The optimization of the breeding techniques of the fish with economic value and the efficient valorization of the natural and additional food resource. *Fascicle VII, Fishing and Aquaculture, The Annals of „Dunărea de Jos” University of Galaţi, XXIII*, 16.

Dobrotă, N.G., Dobrotă, G., Cristea, V., & Costache, M. (2022). The influence of the stocking density on the survival rate of the pike-perch (*Sander lucioperca* – Linaeus, 1758) during the cold season in industrial aquaculture systems. *Scientific Papers. Series D. Animal Science*, *LXV*(2), 491-498.

Gheracopol, O. (1971). Observations on the change of some morphological and biochemical indices in cultured carp, during the winter period. *Studii şi Cercetări Piscicole , IV* (VII), 253-271.

Hokanson, K. E. F. (1977). Temperature requirements of some percids and adaptations to the seasonal temperature cycle. *Journal of the Fisheries Board of Canada*, *34*(10), 1524- 1550.

Latiu, C., Constantinescu, R., Miresan, V., Nicula, A. S., Dumitras, D. E., Papuc, T., Uiuiu, P., & Cocan, D. (2022). Length-weight relationships and Fulton condition factor (K) of freshwater fish species from the Ruscova River, spawning ground of Danube salmon *Hucho Hucho*, Linnaeus, 1758 (Pisces: Salmonidae). *Scientific Papers. Series D. Animal Science, LXV*(1), 607-611.

Lemasson, A. J., Hall-Spencer, J. M., Fletcher, S., Provstgaard-Morys, S., & Knights, A. M. (2018). Indications of future performance of native and non-native adult oysters under acidification and warming. *Marine environmental research*, *142*, 178–189.

Marcogliese, D.J. (2008). The impact of climate change on the parasites and infectious diseases of aquatic animals. *Revue scientifique et technique (International Office of Epizootics)*, *27*(2), 467–484.

Ministry of the Environment and Water Management (MEWM) (2006*). Order no. 161 on February 16, 2006 for the approval of the Normative regarding the classification of surface water quality in order to establish the ecological status of water bodies*. Official Monitor no. 511 on June 13, 2006. Retrieved August 25, 2023, from https://legislatie.just.ro/Public/DetaliiDocumentAfis/72574.

Ngoan, L. D. (2018). Effects of Climate Change in Aquaculture: Case study in Thua Thien Hue Province, Vietnam. *Biomedical Journal of Scientific & Technical Research,* 10(1), 75517552. DOI: 10.26717/BJSTR.2018.10.001892.

Oprea, L., & Georgescu, R. (2000). *Fish nutrition and feeding*. Bucharest, RO: Tehnica Publishing House.

Popa, M. D., Mocanu, E., Savin, V., Dima, F., & Patriche, N. (2022). Macronutrients modification in the muscle of common carp (*Cyprinus carpio*) during winter. *Scientific Papers. Series D. Animal Science, LXV*(1), 648-653.

Sae-Lim, P., Kause, A., Mulder, H. A., & Olesen, I. (2017). Climate change and selective breeding in aquaculture. *Journal of Animal Science, 95*(4), 1801–1812. DOI: 10.2527/jas2016.1066.

Savin, V., Mocanu, E., Dima, F., Patriche, N., Popa, M. D., & Cristea, V. (2022). Research on the Fulton condition factor, the hepato-somatic index and the biochemical composition of carp (*Cyprinus carpio*) from 3 different sources, in Romania. *Scientific Papers. Series D. Animal Science*, *LXV*(2), 409-414.

Thangaraji, R., Neethirajan, N., Natarajan, J., Chandran S., Thavasiyandi, U., & Pandurangan, P. (2023). Length-weight Relationships and Fulton's Condition Factor (K) for 29 Demersal Reef Fishes Caught by Longline. *Thalassas: An International Journal of Marine Sciences*, *39*, 1263-1270.