KAPITEL 9 / *CHAPTER 9* [9]
WINTERING OF CARP IN POLYCULTURE UNDER THE IMPACT OF GLOBAL WARMING IN SOUTHERN UKRAINE

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Introduction

Pond fish farming is the main direction of fishery activities in inland waters of Ukraine. In the conditions of modern climate change and in the conditions of hydrological and hydrochemical regime of ponds, technological parameters, functional status of fish, productivity - all these indicators require review by scientists and practitioners [1, 6, 14, 17]. It is urgent to conduct relevant special scientific research works, experimental studies.

In recent years, fisheries in southern Ukraine have suffered significant losses due to low rates of annual fish hatchery production in the post-winter period. Particular attention is required to the air temperature, which affects artificial water areas with a relatively small area combined with a small volume [6, 7]. This is a characteristic feature of ponds that are part of fish nurseries and full-system warm-water pond fisheries. Against the background of an increase in the growing season, the winter period has shortened, and the winters themselves have become less cold, which accordingly affects the effectiveness of overwintering of fish seedlings [26, 27].

Today, in the scientific and practical literature, authors note the importance of harmonizing biological and technological parameters in fisheries and aquaculture. They pay attention to adaptogens, biological components of natural nature, optimization of juvenile rearing technology, etc. [8, 12, 15]. Modern factors, including climate change, technogenic load - all this has a negative impact on the ecosystem, indicators of ontogenesis of aquatic organisms, their productivity, development, physiology and other indicators [25, 10, 11]. Experience in optimizing technological conditions in fish farming demonstrates that a positive result can be obtained if the technological scheme is comprehensive, providing for all abiotic and biotic conditions [8, 9, 22, 23, 28].

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9.1. Aspects of the regional context

For the Southern part of Ukraine, when conducting fisheries activities, it is important to follow the recommendations based on the characteristics of climatic parameters [23, 28]. The location in the continental region of the temperate climate zone is characterized by a temperate continental climate with a mild, unstable winter and hot, dry summer. Such a climate is formed under the influence of a complex of factors. The magnitude of total solar radiation depends on the geographical latitude. The formation of the climate of the Kherson region is greatly influenced by the location of the region in the low pressure belt of temperate latitudes, the dominance of temperate (marine and continental) air masses, as well as cyclones of the Black Sea, Atlantic and Mediterranean Sea. In this case, it is important to take into account the influence of the Azov anticyclone [2, 24].

The steppe zone of our country is characterized by a moderately warm climate with insufficient moisture. At the same time, the soil is characterized by diversity. There are both sandy and peaty areas. The annual radiation balance is 50-57 kcal/cm. The duration of the growing season is 210-245 days. With the warmest month of July (when the average monthly temperature is 23-25°C, and the maximum temperature is 38-41°C). In January, the temperature is on average 7°C. The number of days with a temperature above 15°C is 120-130 [16]. The coldest month in the growing season is September (with an average temperature of 14.8°C). In contrast, the warmest month is July (when the thermometer shows 23°C). The average annual air temperature is 10°C with the sum of temperatures from May to September 2801-3182°C. The average annual precipitation varies from 300 to 600 mm, evaporation from 700 to 1000 mm [3, 5, 27].

Thus, the Kherson region has a continental type of annual precipitation, in which the amount of precipitation in the warm period is 300-400 mm, with evaporation from 1000 to 1050 mm (prevails over the amount of precipitation in the cold period).

The duration of the growing season is from 215 to 225 days, and without frost, from the last frost in spring to the first in autumn - from 175 to 180 days [16, 23].

The practical base for the implementation of complex works - the Kherson Production and Experimental Plant for Breeding Young Partial Fish - is located in the continental region of the climatic zone of Ukraine of temperate latitudes. It is characterized by a temperate-continental climate with mild, short-lived winters and hot, dry summers.

9.2. Technological aspects

The regulatory basis for the development of a set of measures was: the Law of Ukraine "On the Animal World"; Instructions on the procedure for artificial breeding, growing fish, other aquatic living resources and their use in special commercial fish farms; Instructions on the procedure for special use of fish and other aquatic living resources; Instructions on the procedure for carrying out work on the reproduction of aquatic living resources, etc. Hydrochemical, morpho-physiological studies were carried out according to generally accepted methods. Wintering ponds in fish farms of the Southern region of Ukraine are used for different age groups of heat-loving fish species, namely yearlings of carp and herbivorous fish. Nowadays, the vast majority of farms implement the process of wintering yearlings based on outdated existing standards.

Given that modern conditions are significantly transformed, the features of southern Ukraine against the background of the current general warming of the atmosphere, turned out to be the most sensitive to the wintering of this year's carp fish. It is important to take into account the outlined aspects, including that the water temperature for hydrobionts (carp in polyculture when growing and breeding especially in ponds) plays a key role in the intensity of their development in ontogenesis and other biological processes.

It should be noted that modern insufficiently cold winters, the absence of ice formation provoke fish that winter to active behavior. As a result, this leads to the loss of reserves of the fish organism, their exhaustion, and as a result, an increase in the

departure of fish after wintering.

When forming the experimental groups, the recommended regulatory data on the density of carp planting in polyculture for the Southern region of Ukraine were taken into account and based on (Table 1).

Table 1. Fish wintering standards

Indicator, units of measurement	**Type of fish**	**Polissya** *(III)*	**Forest-steppe** *(IV)*	**Steppe** *North (V)*	**Steppe** *South (VI)*
Wintering ponds: area, ha depth of the non-freezing layer, m		0,5 – 1,0 1,2	0,5 – 1,0 1,2	0,5 – 1,0 1,2	0,5 – 1,0 1,2
Water exchange, day		15-20	15-20	15-20	15-20
Planting density of annuals, thousand specimens/ha	C*	600	650	700	450
	P*	450	450	500	550
The emergence of annuals from wintering ponds, %	C*	75	80	80	85
	P*	75	80	80	85
Mass losses during wintering, %		12	12	11	10

* Polyculture: C (*carp*) - *Cyprinus carpio; P (*polyculture*)* - *Ctenopharyngodon idella, Hypophthalmichthys molitrix / Hypophthalmichthys nobilis*

9.3. Practical part of the work

The objects of research are presented in the following Fig. 1.1. Based on the characteristics of the farm's pond areas, it should be noted that the enterprise is a fish hatchery, an enterprise that effectively stocks the reservoirs of the Lower Dnieper.

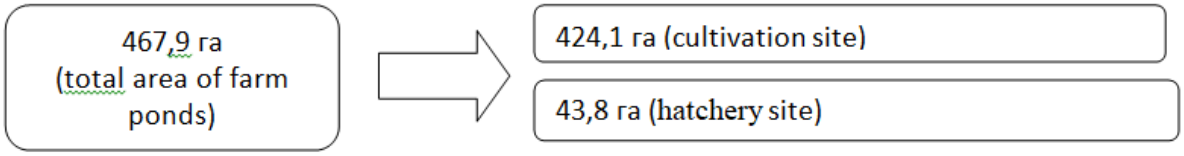

Figure 1.1 - Characteristics of the practical basis of experimental research

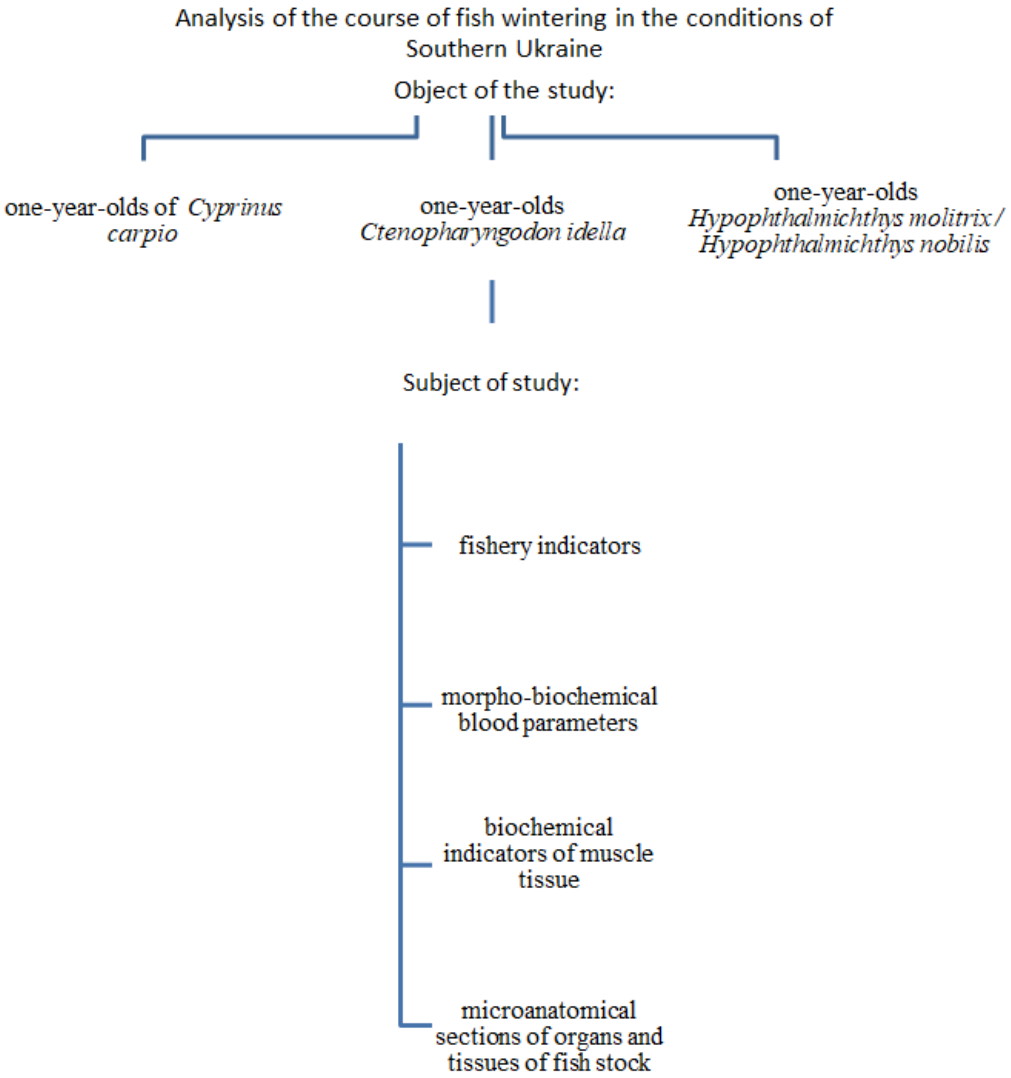

Figure 1 - Algorithm and research basis

The pond fund includes all land plots that are used and occupied by artificial reservoirs intended for certain technological processes. The fishery includes a growing and hatchery area, an incubation workshop with a capacity of 45 million pieces larvae, water supply, discharge and drainage pumping stations, as well as two boiler houses. The research was conducted on the basis of the above-presented fishery of the State Enterprise "Kherson Experimental Production Plant for Breeding of Young Partridge Fish" (Ukraine). Monitoring of the leading parameters was carried out using generally accepted methods in fish farming, hydrochemistry, and physiology [4, 19, 20]. Histological analysis was performed using the author's method (Kozy M.S., 2009) [13, 21]. Laboratory conditions were used, as well as a professional weather station

Ambient Weather AW007 with the UC20GC-128 STD module.

9.4. Main results and discussion

The dynamics of degree-days demonstrates a typical temperature pattern for the south of Ukraine, but not optimal, but significantly higher for wintering in carp ponds of the southern region.

After wintering, losses in linear-weight sizes during the winter period were within 18 - 32%, but the yield and survival after wintering in the middle group for all species was lower than in fish with a "large" size. This difference can be explained by a larger reserve reserve in fish and, accordingly, better metabolic processes, their physiological state.

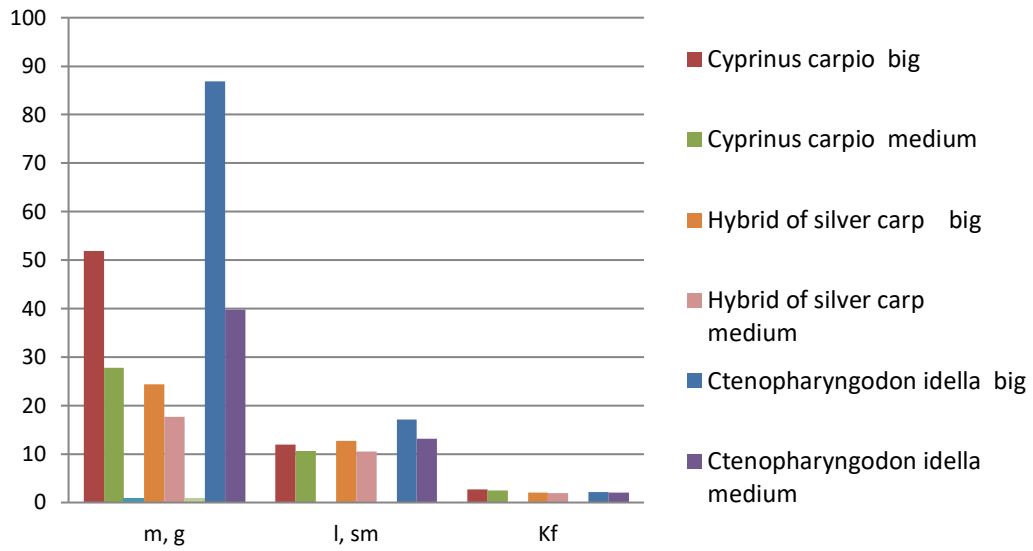

Figure 2 - The effect of wintering on linear dimensions (l, cm; average body weight, g) and fattening coefficient Kf in cyprinids before winter

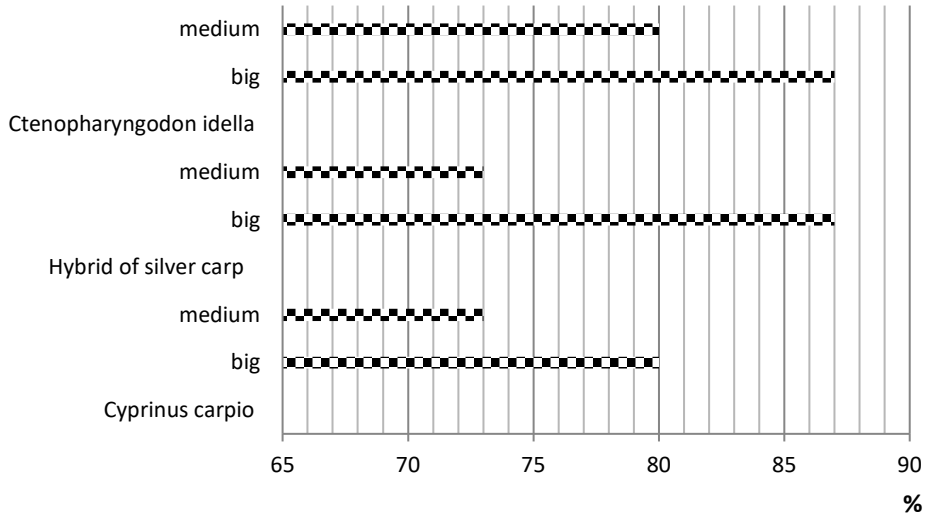

Figure 3 - Survival after wintering, %

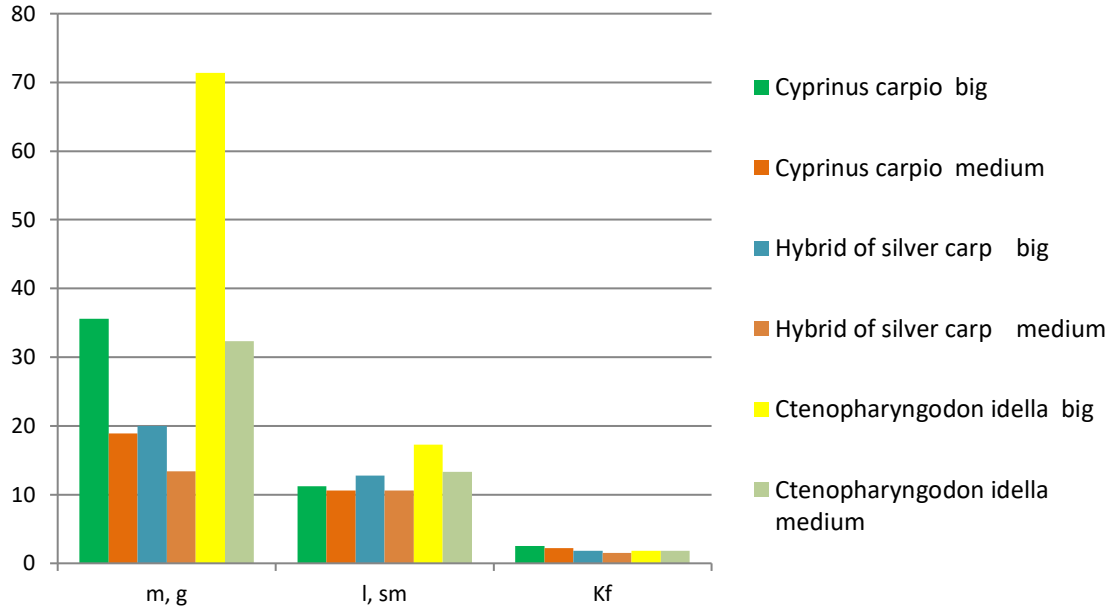

Figure 4 - The impact of fish wintering on linear measurements after wintering

Analyzing the trend of changes in blood composition parameters in fish depending on the influence of the seasonality factor, we can conclude that metabolism and synthesis processes influenced the rate of fish development. Homeostasis parameters corrected the rate of body weight loss, as well as its accumulation during wintering. The percentage of fish survival was also correlated. It is important to note that physiological and biochemical parameters had a direct and indirect effect on the morphometric, meristic and plastic indicators of fish. The content of total protein

before wintering in fish was a minimum of 15.25 and a maximum of 24.36 g/l (Table 2,3). Seasonality and all related factors contributed to a greater decrease in this indicator after wintering, on average by 5.55%.

Table 2. Analysis of the blood composition of carp in polyculture before winter, X ± SD, n=12

Parameters	*Cyprinus carpio*		*Hypophthalmichthys molitrix / Hypophthalmichthys nobilis*		*Ctenopharyngodon idella*	
	big	medium	big	medium	big	medium
Total protein, g/l	22,38±0,98	23,15±0,90	20,16±0,56	16,46±0,75	24,36±1,16	15,25±0,90
Albumin, g/l	6,49±0,36	6,01±0,28	5,72±0,33	5,76±0,75	6,48±0,74	9,40±0,68
Creatinine, mg/dl	0,09±0,01	0,08±0,01	0,07±0,01	0,30±0,02	0,10±0,01	0,35±0,01
Triglycerides, mg/dl	139,68±6,68	134,89±10,13	131,99±2,80	69,52±0,92	142,49±2,97	51,35±4,49
Cholesterol, mg/dl	141,03±10,06	126,44±11,78	120,10±0,85	108,29±15,62	118,48±3,16	129,92±1,78
Calcium / Phosphorus, mg/dl	7,69±0,18/ 18,84±1,40	7,61±0,19/ 20,25±1,30	6,78±0,29/ 12,70±0,37	6,93±0,35/ 13,83±0,66	7,66±0,33/ 13,50±0,40	4,85±0,37/ 16,83±0,49

Table 3. Analysis of the blood composition of carp in polyculture after wintering X ± SD, n=12

Parameters	*Cyprinus carpio*		*Hypophthalmichthys molitrix / Hypophthalmichthys nobilis*		*Ctenopharyngodon idella*	
	big	medium	big	medium	big	medium
Total protein, g/l	22,25±1,29	21,25±1,03	21,86±1,15	18,70±0,82	23,72±2,27	14,15±1,21
Albumin, g/l	16,71±3,24	23,65±3,92	6,73±0,50	5,88±0,16	6,13±1,05	9,87±1,69
Creatinine, mg/dl	0,35±0,01	0,34±0,08	0,10±0,01	0,30±0,01	0,10±0,01	0,28±0,02
Triglycerides, mg/dl	125,57±3,56	128,00±3,49	124,47±1,20	65,08±4,58	141,01±1,91	48,76±1,05
Cholesterol, mg/dl	103,28±7,79	100,31±6,57	114,39±5,45	72,34±0,85	116,24±2,27	121,79±15,84
Calcium / Phosphorus, mg/dl	6,63±0,49/ 11,34±0,22	5,22±0,40/ 11,50±0,15	5,55±0,27/ 12,24±0,80	6,37±0,55/ 7,86±0,52	5,73±0,77/ 12,77±1,62	2,73±0,20/ 16,42±0,49

The moisture, protein and ash content was at the optimal level to ensure the physiological needs of the fish. The fat percentage did not meet the recommendations. After wintering, a natural increase in the moisture and ash content in the muscles of all groups of carp in polyculture was observed.

In the body, protein loss in "large" fish was within the limits: for carp - 18%, for hybrid silver carp - 29%, and for white grass carp - 12%. Analysis of fish with an "average" size showed that in yearling carp this parameter was 23%, for hybrid silver carp - 35%, while for white grass carp this parameter was 22%.

Fat loss in yearlings of the large group was within the limits: carp – 39%, hybrid silver carp – 44%, grass carp – 35%; in yearlings of the medium group: carp – 49%, hybrid silver carp – 51%, grass carp – 49%. When comparing the fat content in the muscles before and after wintering, an activation of metabolic processes was also noted.

Analysis of histological parameters demonstrated that during the wintering period, specific processes occurred in the fish body. A decrease in the activity of gland secretion was noted, which also corrected the activity of the fish digestive systems. In this case, this was most clearly seen in the structure of the hepatopancreas of the Ctenopharyngodon idella (Fig. 5).

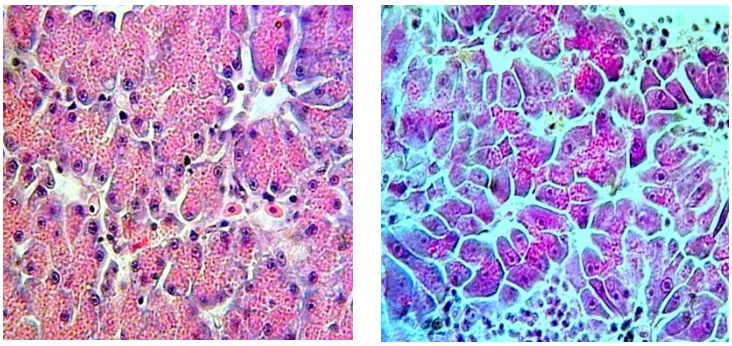

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Figure 5 - Analysis of structural parameters of the hepatopancreas of Ctenopharyngodon idella before the beginning of wintering (1) and after wintering (2). Boehmer's hematoxylin, Hart's fuxelin (modified). Correction filter "ZhZM 2.5X" (1), "MONOCHROM 2.5X" (2), X200

Analysis of the figure provides grounds to note that the cells that form the terminal sections of the exocrine part of the grass carp organ are tall and cone-shaped. Their nuclei are rounded, oriented towards the basal part of the cells. The apical ends of the cells are oxyphilic, and the basal ends acquire the tone of the main dye. The terminal section and lobules of the gland are surrounded by layers of loose connective tissue.

Among the characteristic features of exocrinocytes (acinocytes) of the hepatopancreas is a peculiar "foaminess" of the cytoplasm, which is observed in their apical part. The specific type of cells is due to the fact that proteinases and lipases are

secreted when they are in an active form. In pancreatic exocrinocytes, theyproteinases and lipases have the form of zymogen granules. The established characteristics are characteristic of fish in optimal conditions of existence, without stress factors. In the winter period, the intensity of zymogen biosynthesis is significantly reduced, as a result of which the homogeneous pole of acinocytes prevails over zymogens. Wintering is a peculiar factor as a stress [18].

The specificity of the structure of the mesonephros and its functioning in fish are associated with the peculiarities of osmoregulation in a certain period of the season, which is regulated against the background of changes in the physicochemical parameters of the environment. The structure of the mesonephros of fish in wintering conditions is shown in Fig. 6.

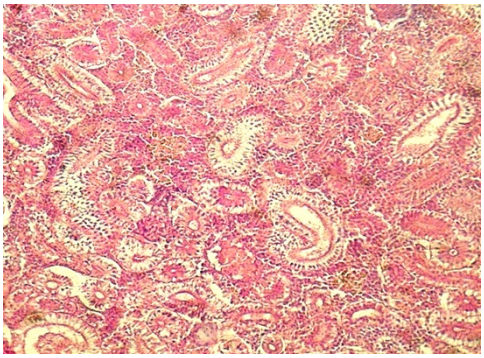

Figure 6 - Mesonephros of annuals Hypophthalmichthys molitrix / Hypophthalmichthys nobilis in wintering conditions Boehmer's hematoxylin, Hart's fuxelin (in modification). X120

The space between the leaves of the Bowman-Shumlyansky capsule is narrow, which indicates the presence of a small volume of primary filtrate in the capsular cavity. The discovered fact indicates the ability of the nephron to smoothly compensate for water losses from the body, which is characteristic of peak seasonal changes in oxygen and temperature. In this case, this is the wintering of fish.

Summary and conclusions

The dynamics of changes in air and water temperature against the background of other meteorological parameters provides an opportunity to more comprehensively assess the impact of global warming on the wintering of carp fish in the conditions of ponds in southern Ukraine. The temperature of the pond water during the wintering of carp fish was within 4.48°C - 5.69°C. At the same time, the minimum values of water temperature were recorded in January, and the maximum in October.

Against the background of air temperature in October and minimum in February. The dynamics of degree-days demonstrates a typical temperature pattern for the South of Ukraine, but not optimal, but significantly higher for wintering in ponds of carp fish of the Southern region of our country.

The results of the studies demonstrate the negative impact of wintering and the reduction of winter temperature ranges on the morphofunctional state in the body of fish stock in the conditions of ponds of southern Ukraine. The reason for this may be the general warming of the climate of southern Ukraine by 1.2 - 1.5^0C. Under these conditions, the fish were in the optimal wintering temperatures of adaptive and compensatory mechanisms for one month. At a range of wintering temperatures above the optimal ones, fish stock of carp fish species actively spent nutrient reserves against the background of body weight loss and general exhaustion, which negatively affected the physiological and biochemical indicators of blood, muscle part and microlevel changes in fish organs and tissues.

The results obtained confirm the impact of climatic transformations on the general physiological state of the organism of carp *(Cyprinus carpio)* fish stock in polyculture with herbivorous fish: grass carp and hybrid silver carp *(Ctenopharyngodon idella, Hypophthalmichthys molitrix / Hypophthalmichthys nobilis)* during the wintering period. The emphasis is on the conditions of southern Ukraine. It was established that the recorded changes in air temperature during the winter correlate with the temperature and oxygen regime of wintering ponds. Against this background, there is an impact on the main fishery indicators of this year's and one-year-old carp in

polyculture with herbivorous fish. The main fishery indicators of fish change, including the fattening coefficient, the percentage of fish survival after wintering, and morphometric indicators.

The results are supplemented by a biochemical analysis of muscle tissue, blood, and histology of fish organs and tissues.

A new concept of optimizing the technological aspects of growing young fish, fish stock is proposed. The emphasis is on optimizing the course of wintering of carp and herbivorous fish, taking into account the reduction of the ice-free period on wintering ponds. Simultaneously with the use of increased fish stocking density, there is an overtime consumption of nutrient reserves in their body. The results are confirmed by biochemical parameters, blood composition, and histological analysis.

Optimization of the technological process, which consists in changing the technology of growing fish stock from a two-year turnover to a one-year one, excluding the wintering period in artificial wintering ponds from the technological process, which under modern climatic conditions of southern Ukraine negatively affects the physiological state, fishery indicators and economic efficiency of the production of introduced fish for further stocking of natural water areas.