ACTA HYDROBIOL.	27	2	229—239	KRAKÓW 1985

Studies on intensification of carp farming

9. State of health and haematological indices of carp in productive ponds*

Andrzej Pilarczyk

Polish Academy of Sciences, Fish Culture Experimental Station
Gołysz, 43-422 Chybie, Poland

Manuscript submitted June 30, 1981, accepted July 20, 1984

Abstract — To estimate the possible effects on the fish of experiments on intensive carp farming in ponds at Gołysz, ichthyopathological investigations were carried out in the productive ponds with the aim of evaluating the state of health of the fish. At all levels of intensification deviations from the norm of some indices and certain pathological changes were found. Nevertheless the results did not indicate any decidedly unfavourable effect of the intensification on the fish reared.

Key words: ponds, carp farming, production intensification, pathology, haematology.

1. Introduction

Intensified production affects the environment and living conditions of fish and it is of great practical importance to know the factors influencing their organism. Observations of the state of health fish and certain physiological indices of the organism may be a basis for determining the optimal level of intensification and finding out the point at which stock density may endanger fish health.

Hitherto the effects of various foods and rearing conditions on the haematological indices have been investigated (Golodyets 1954, Łysak, Wójcik 1960, Kudryashova 1969, Ivanova 1973), while the occurrence of external parasites under the conditions of in-

* The work was supported by Research Project No 136 of the Ministry of Agriculture.

tensive production (Migała 1970) has also been studied. The influence of fertilization on the fish organism was dealt with as well (Markiewicz et al. 1977, Svobodová, Havelka 1977).

Ichthyopathological and haematological investigations were carried out in experimental ponds at Gołysz in the years 1971—1973 (Markiewicz et al. 1985). The changes in the fish organism were found to be the effect of several factors, the most important among them being the fish stock density, the kind of food, climatic conditions, and environmental changes in the ponds.

2. Material and methods

The investigations presented here were a continuation of those begun in experimental ponds in the years 1971—1975 (Szumiec 1985a,b) and aimed at confirming the results obtained in the conditions of intensive carp farming in productive ponds.

In 1973 the fish of two ponds were examined. One of them, the control (T), was stocked with 1200 C_2 ha^{-1} throughout the period of investigation. The stock was similar to the average in most of the productive ponds of the Station. The fish were fed on traditional feeds, i.e. post-extract meal and barley. The other one, farmed intensively (P_L), was stocked with 4000 C_2 ha^{-1} and the fish were fed on pellets containing 30% protein.

In 1974 carp from five ponds were examined, besides the control pond (T) fish from intensive ponds being taken. In the pond (M) stocked with 3000 C_2 ha^{-1}, representing an average level of production, the carp were fed on soya and in the remaining ones on pellets containing 20—35% protein. The stock here was 4000 C_2 ha^{-1} in pond (P_L) and 5000 or 6000 C_2 ha^{-1} in ponds (P_H).

In 1975 fish from four ponds were examined, i.e. from the control one (T) stocked and fed as during the previous years and from three ponds with an intensive level of production. In one of them (M) stocked with 3000 C_2 ha^{-1} the fish were fed on wheat in May and September and in other months on pellets. In the remaining two ponds pellets containing 30% protein were given. The pond (P_L) was stocked with 5000 C_2 ha^{-1} but pond (P_H) with 5000 C_2 and 1000 Sc_2 ha^{-1}.

Each year the ponds were stocked with the same material coming only from one pond. Before stocking the fish were injected with chloramphenicol in the dose 20—25 mg per 1 kg of body weight. During the farming season the same fertilization and liming in all the ponds were applied. In the intensive ponds during the periods of oxygen deficiency the water was aerated.

Five fish from each pond were sampled every month. Altogether 70

in 1973, 155 in 1974, and 100 fish in 1975 were examined. During periods of oxygen deficiency no samples were taken.

Similarly to those carried out in experimental ponds (Markiewicz et al. 1985), morphological, anathomopathological, parasitological, and haematological examinations were made all the time. Haematological examination included determination of the haemoglobin content and hematocrit, calculation of the mean corpuscular haemoglobin concentration (MCHC) and analysis of blood smears. These ichthyopathological and haematological investigations were carried out according to the generally used methods (Łysak 1959, Kocyłowski, Miączyński 1960, Amlacher 1972, Blaxhall, Daisley 1973, Kreutzmann 1974). Blood for tests was taken from vena caudalis. Haemoglobin was determined by the cyanmethemoglobin method, using Drabkin's reagent. The level of protein was determined with a refractometer.

During the ichthyopathological investigations the general condition of the fish, changes in the skin and gills, abdominal cavity, and internal organs were considered. The percentage of fish with pathological changes in different ponds was compared.

3. Results

The fish survival rate in the investigated ponds was high and the state of health of the fish satisfactory (Table I). Mortality amounting to 2—10% and even to 25% in the pond (P_L) in 1974 were caused by oxygen deficiency.

There were no distinct differences in the general fish condition and pathological changes between carp from the intensive and the control ponds. The changes occurring were non-significant.

Table I. Survival rate in separate group of ponds in % in the period 1973-1975. Group of ponds: T control; M average level of production, soya feed or pellets in high season and wheat in May and September; P_L ponds of intensive production with lower level of production, pellet feed; P_H ponds of intensive production with higher level of production, pellet feed

Group of ponds	1973	1974	1975
T	89.5	97.0	80.5
M		92.2	96.6
P_L	96.9	72.9	82.2
P_H		96.5	88.3

Examination of the stocking material carried out in spring showed effusion (100% in 1975 and 80% in 1973), congestion in the gills and skin (100% in 1975), increased excretion of mucus, and leucocyte infiltrations in the gills (40%). Cholestasia was found in about 40% of fish. Adhesions of the internal organs were also sporadically present (Table II).

Table II. Pathological signs observed in the carp examined in the period 1973-1975. Group of ponds: T - control; M - average level of production, soya feed or pellets in high season and wheat in May and September; P_L - ponds of intensive production with lower level of production, pellet feed; P_H - ponds of intensive production with higher level of production, pellet feed. C_2 - two year old carp; So_2 - two year old silver carp. + - changes in 20% examined fish

Year	Stock number/ hectare	Group of ponds	Months	Percentage of fish with pathological signs found in:						
				skin	gill	abdominal cavity	kidney	hepato-pancreas	spleen	swim bladder
1973		fish stock	IV	+	+	+ + + +		+ +		+
	1200 C_2	T	V	+ + +	+ + + + +	+ + + +	+ +	+		+
			VI	+ + +	+ + + +	●	+	+ + +		
			VII	+	+ + + +		+	+ +		+ +
			VIII	+	+ + +			+ +		
			IX	+	+ +					
	4000 C_2	P_L	V	+	+	+	+ +	+		+ + +
			VI	+ + +	+ +	+		+ + + +	+ +	
			VII	+ + +	+ +			+ + +		
			VIII	+	+ + +			+		
			IX	+	+ + +	+ + +	+		+	
1974	1200 C_2	T	V							
			VI	+	+ + + + +					
			VII	+ + +	+ + + +		+ +	+ +		
			VIII	+ + +	+ + + +		+ + +	+ + +		
			IX	+ +	+ + + +	+	+ + + +	+		
	3000 C_2	M	V		+					
			VI		+ +			+		
			VII	+ +	+ + +		+ + +	+	+	
			VIII	+	+ + + +		+	+ +		
			IX		+ + +					
	4000 C_2	P_L	V		+					
			VI	+ +	+ + +		+ +			
			VII	+ + +	+ + + +		+ + + + +	+ + + + +		
			VIII	+ + + +	+ + + + +		+ + + +	+ + + + +		
			IX	+ + +	+ + +		+ + +	+ + +		
	5000 C_2	P_H	V	+	+			+		
			VI	+ + + +	+ +			+ + +		
			VII	+ + +	+ + +	+	+ +	+ +		
			VIII	+ + +	+ + + + +	+	+ + +	+ + + +		
			IX	+ +	+ + + +		+ + +	+ + +		
1975		fish stock	IV	+ + + + +	+ +	+ + + + +	+			
	1200 C_2	T	V	+ + +	+ + +	+ + + + +	+ + + + +			
			VI	+ + + +	+ + +			+ + +		
			VII	+ +						
			VIII	+						
			IX							
	5000 C_2	M	V	+ + + +	+ + + + +	+ +	+ + +			
			VI	+	+ +		+	+ + +		
			VII		+					
			VIII		+					
			IX							
	5000 C_2		V		+ + +					
			VI	+	+ + + +		+ + +	+ + + +		
			VII		+			+ + + +		
			VIII	+						
			IX	+	+					
	5000 C_2 1000 So_2	P_H	V	+ + +	+ + + +	+ +		+ +		
			VI	+ + +	+ + + +					
			VII	+	+			+ + +		
			VIII							
			IX							

During the season changes in the skin such as slight bleeding and increased excretion of mucus (20—60% of carp), occurred in all the ponds considered. Fairly frequent and distinct changes were observed in the gills. These were oedema, increased mucus excretion, congestion, and local necrosis causing anabrosis of the respiratory epithelium. They appeared with varying intensity in all the ponds (Table II). In 1973 in pond (T) the whole stock was effected with gill necrotic disease while in other years the gill changes in this pond were slightly less distinct than in other ponds. The greatest gill changes in pond (T) occurred at the beginning of June but in the remaining ponds at the end of July. 60—100% of carp gills were affected in 1973 and 1974 and only 20—80% in 1975.

There appeared no effusions in other season but hepatopancreatic changes up to 20—100% were observed (Table II), being usually more common with fish from the intensive ponds and appearing as anaemia or lipomatosis. Oedema of the kidney was observed mostly in 1974. Oedema of the spleen, inflammation of the swim bladder and adhesions of internal organs were also present but sporadic.

Altogether as many as fourteen kinds of parasite were found: 1 species of fungus, 8 genera of *Protozoa*, 3 genera of *Monogenea*, 1 genus of leech and 1 species of *Crustacea* (Table III). The extent of invasion depended on the species of the parasite and the kind of pond investigated. The low pathogenic parasites, *Trichodina* sp. and *Glossatella* sp., manifested the highest extent, from 20% to 100%, but the intensity of invasion was low, showing only 10 parasites in the field in three samples. *Monogenea*, *Dactylogyrus* sp. and *Gyrodactylus* sp. were fairly common, their extent and intensity being higher in heavily stocked ponds. An exception was one of the (P_H) ponds where no *Monogenea* were found in 1975. The heavy stock density also caused a higher intensity and extent of invasion of *Piscicola* sp. and *Argulus* sp. The appearance of other parasites was sporadic. The numbers of parasites found, however, posed no threat to intensive carp production since during the years of the experiment parasites were not found to have caused any distinct pathological changes or mortality.

The purpose of analysing the haematological indices was to determine disturbances in the carp organism affecting their blood composition. The results obtained did not show any distinct haematological differences between the carp fed on different foods and coming from ponds with various stock density. However, certain characteristic changes were observed in all the fish examined, such as a low haemoglobin level throughout the farming season. The haemoglobin content fell to 6.0—6.5 g% in April and May, its level usually being below 7 g% in July and August. It was only in September that it reached 8—9 g% at the end of the farming season and was higher in carp from the intensive ponds.

Table III. Results of parasitological investigations in the period 1973-1975, extent of parasitic invasion in percentage/maximum number of parasites in the field or on the body in the case of Argulus and Piscicola. Group of ponds: T - control; K - average level of production, soya feed or pellets in high season and wheat in May and September; P_L - ponds of intensive production with lower level of production, pellet feed; P_H - ponds of intensive production with higher level of production, pellet feed. x - no parasites found; — - fish not examined

Kind of parasite	Months / Year	Group of ponds																			
		T					K					P_L					P_H				
		M	J	J	A	S	M	J	J	A	S	M	J	J	A	S	M	J	J	A	S
Trichodina sp.	1973	60/6	60/4	40/8	60/2	40/3	-	-	-	-	-	40/2	80/10	40/3	60/8	40/2	-	-	-	-	-
	1974	20/2	20/2	20/2	20/2	20/2	20/2	40/3	20/2	40/3	20/2	20/2	60/10	40/4	20/2	60/5	30/2	20/2	20/2	80/3	20/2
	1975	60/5	20/2	40/2	20/2	40/3	60/5	80/3	60/10	60/4	60/4	20/2	60/3	60/3	80/8	40/4	40/2	80/8	60/5	40/3	40/2
Glossatella sp.	1973	x	x	x	40/3	40/2	-	-	-	-	-	x	40/6	20/2	20/2	x	-	-	-	-	-
	1974	x	x	x	x	x	x	x	x	x	x	x	x	x	40/4	x	x	20/3	30/4	x	x
	1975	40/3	x	x	x	40/4	40/3	x	x	x	40/5	20/3	20/3	x	40/6	60/15	x	x	x	x	x
Dactylogyrus sp.	1973	x	x	20/2	x	x	-	-	-	-	-	x	x	20/2	20/2	x	-	-	-	-	-
	1974	x	x	x	20/2	80/4	x	20/2	20/2	60/2	20/2	x	20/2	100/8	40/3	80/4	x	20/4	40/3	60/2	100/6
	1975	x	x	80/6	x	x	x	x	20/2	x	x	x	x	40/4	20/2	x	x	x	x	x	x
Cyrodactylus sp.	1973	x	x	x	x	x	-	-	-	-	-	x	x	-	x	x	-	-	-	-	-
	1974	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	1975	x	x	x	x	x	x	x	60/5	x	x	x	20/2	20/2	20/2	x	x	x	x	x	x
Chlodonella cyprini	1973	x	x	x	x	x	-	-	-	-	-	x	x	x	x	x	-	-	-	-	-
	1974	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	1975	20/2	x	x	x	x	20/2	x	x	x	x	20/3	20/2	x	x	x	x	x	x	x	x
Eimeria cyprini	1973	x	x	x	x	x	-	-	-	-	-	20/3	20/4	x	x	x	-	-	-	-	-
	1974	20/5	x	x	x	x	100/10	x	x	x	x	40/4	x	x	x	x	100/10	20/5	x	x	x
	1975	x	x	x	x	x	x	60/5	x	x	x	x	x	x	x	x	x	x	x	x	x
Ichthyophtirius multifilis	1973	x	x	x	x	x	-	-	-	-	-	x	x	x	x	x	-	-	-	-	-
	1974	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	1975	20/2	x	x	x	x	20/2	x	x	x	x	20/2	x	x	x	x	x	x	x	x	x
Ichthyobodo neoatrix	1973	x	x	x	x	x	-	-	-	-	-	x	x	x	x	x	-	-	-	-	-
	1974	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	1975	x	x	x	x	x	x	x	x	x	x	x	40/2	x	x	20/2	x	x	x	x	x
Mucophilus cyprini	1973	x	x	x	x	x	-	-	-	-	-	x	x	x	x	x	-	-	-	-	-
	1974	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	1975	x	x	x	x	x	x	x	x	x	x	40/5	x	x	x	x	20/6	x	x	x	x
Crybtobia cyprini	1973	x	x	x	x	x	-	-	-	-	-	x	x	x	20/6	x	-	-	-	-	-
	1974	20/4	x	x	x	x	20/6	x	x	x	x	20/4	x	x	x	x	40/5	20/4	x	x	x
	1975	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Sanguinicola sp.	1973	x	x	x	x	x	-	-	-	-	-	20/2	x	x	x	x	-	-	-	-	-
	1974	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	1975	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Myxobolus sp.	1973	x	x	x	x	x	-	-	-	-	-	x	x	x	x	x	-	-	-	-	-
	1974	x	x	x	x	x	x	x	x	x	x	20/4	x	x	x	x	20/10	x	x	x	x
	1975	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Argulus foliaceus	1973	x	x	x	x	40/4	-	-	-	-	-	x	x	x	20/3	x	-	-	-	-	-
	1974	x	x	x	x	x	x	x	x	x	x	x	40/5	x	x	60/4	x	x	x	40/6	60/3
	1975	x	x	x	x	40/4	x	20/3	20/3	x	60/3	x	40/3	60/5	60/8	60/10	x	x	40/3	40/3	50/5
Piscicola geometra	1973	x	x	x	x	x	-	-	-	-	-	x	x	x	x	x	-	-	-	-	-
	1974	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	1975	x	x	x	40/2	x	x	x	x	x	x	x	x	x	x	100/10	x	x	x	x	x

Hematocrit values, except for the falls in June parallel to those in haemoglobin, were near the norm, i.e. 35%. This fact and the calculation of the mean corpuscular haemoglobin concentration (MCHC) indicate that the observed falls in the haemoglobin content are the effect of a lower concentration of haemoglobin in the erythrocytes. This is caused by an increased number of immature erythrocytes in the peripheral blood and was confirmed by blood smears.

In analysing the leucocyte picture only the relative percentage of lymphocytes was considered. Throughout the season the lymphocytes constituted 90—95% of the leucocytes (figs 1, 2, 3). An exception were

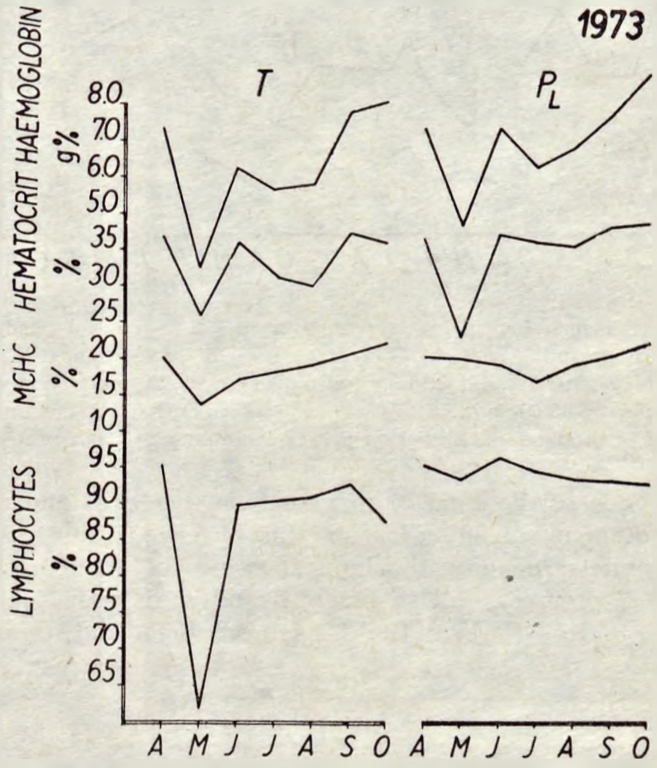

Fig. 1. Results of haematological investigations in 1973. T — control pond, fish fed on rough-ground barley and peanuts; P_L — pond of intensive production, fish fed on pellets containing 30% protein

the fish from pond (T). Here lymphocites constituted only 62.7% in 1973, but the count of neutrophils, eosinophils, and monocytes increased, probably owing to the gill disease observed in fish examined at that time.

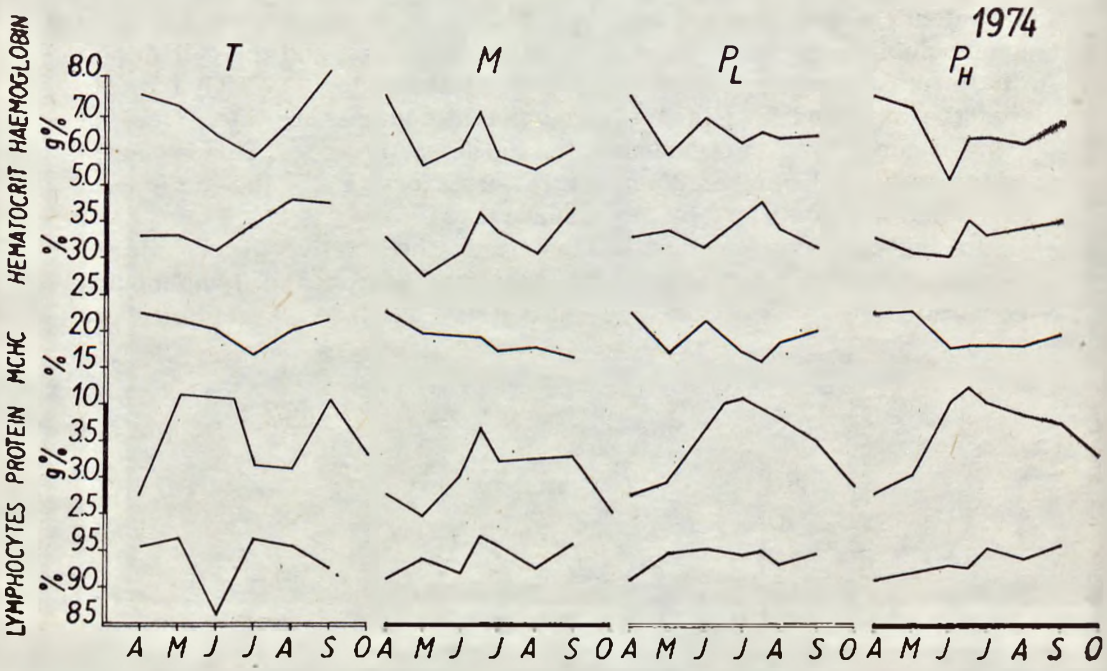

Fig. 2. Results of haematological investigations in 1974. T — control pond, fish fed on rough-ground barley and peanut; M — average level of production, fish fed on soya; P_H — ponds of intensive production with higher level of production, fish fed on pellets containing 30—35% protein; P_L — pond of intensive production with lower level of production, fish fed on pellets-containing 20—30% protein

The influence of the kind of fish food on the level and rate of increase of protein in the blood serum was observed (figs 1, 2, 3) in the fish fed on pellets reaching the highest values of about 4 g% at the beginning of September. In fish fed on traditional foods it had lower values, being under 3.5 g% in the fish fed on wheat and soya.

4. Discussion

The aim of the present work was to analyse changes in the condition, state of health, and certain haematological indices in carp as an effect of intensive fish farming. Such changes are caused by a number of factors, the most important among them being the stock density, kind of food, seasonal climatic conditions, as well as the transformed pond environment.

The skin changes observed are usually a result of rough handling of the fish, scale damage and skin and fin bleeding often being caused by frequent sampling.

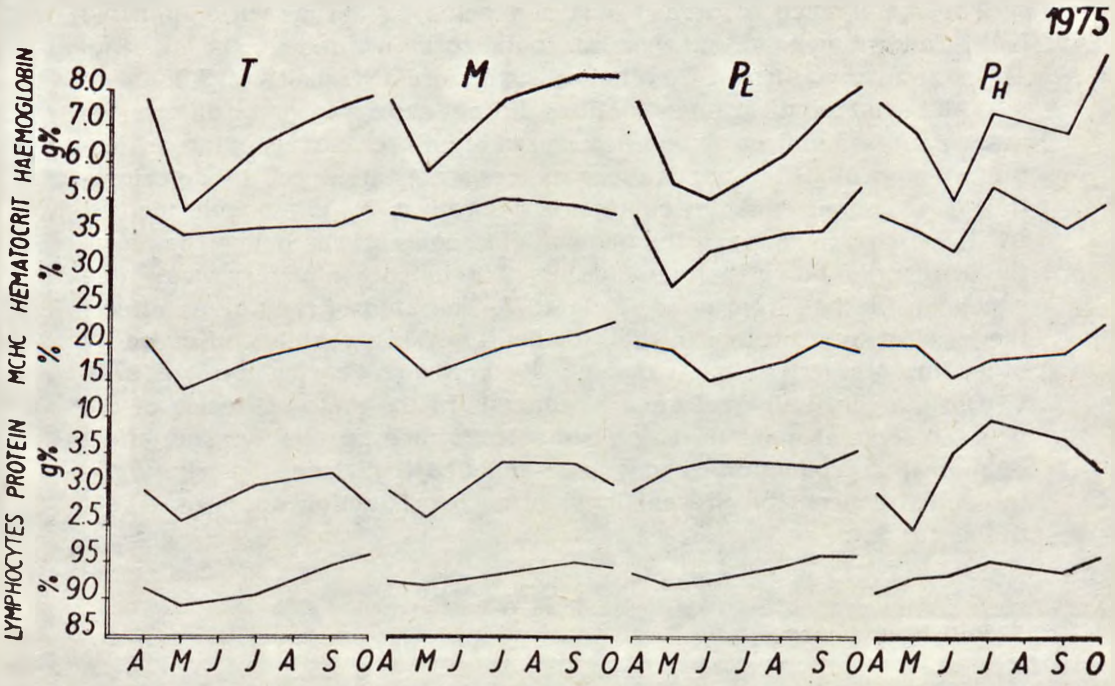

Fig. 3. Results of haematological investigations in 1975. T — control ponds, fish fed on rough-ground barley and peanuts; M — average level of production, fish fed on pellets in high season, on wheat in May and September; P_H — pond of intensive production with higher level of production, fish fed on pellets containing 30% protein; P_L — pond of intensive production with lower level of production, fish fed on pellets containing 30% protein

Gill changes appeared in most of the fish. They were more common with the carp from the ponds with a heavy stock density, undoubtedly resulting from the impaired environmental conditions. The greatest changes were observed in May and June in the ponds with the lowest level of production, gradually diminishing during the following months. Gill changes in carp from the intensive ponds were fairly considerable almost throughout the season. Apart from pond (T) in 1973, the gill changes did not affect the production distinctly but they reduced respiration ability, sometimes causing weakening of the fish and causing them to stop taking food. However, there was no mass mortality. In 1973 the carp from the (T) pond suffered an acute gill disease with some deaths (Pilarczyk 1977). This is expressed in many analysed indices (fig. 1).

There were no distinct changes in the internal organs of fish from different ponds, except from some hepatopancreatic pathological changes in fish reared at the highest level of intensification.

The appearance of parasites is connected as a rule with intensive fish farming but its extent was not found to be a threat to fish rearing. This was also confirmed by other investigators (Migała 1970)

The haematological investigations did not show any great differences in the analysed indices among fish reared at different levels of intensification, though in all the ponds these indices were influenced by deterioration of the environmental conditions as well as by pathogenic factors. In all the cases examined the haemoglobin content was below the norm, the lowest one being in June and July. The leucocyte picture was stable except in the fish from pond (T) in 1973. The kind of food given affects the level of total protein in the blood serum. This was also observed by other authors (Łysak, Wójcik 1960, Markiewicz et al. 1977).

Despite the finding of general changes in the state of health of the fish and some changes in the physiological indices, probably as an effect of intensive production, it may be concluded that, from the ichthyopathological aspect, the present level of such production poses no threat to fish rearing.

5. Polish summary

Studia nad intensyfikacją chowu karpi

9. Stan zdrowotny i wskaźniki hematologiczne u karpi w stawach produkcyjnych

W latach 1973—1975 przeprowadzono badania ichtiopatologiczne i hematologiczne karpi ze stawów produkcyjnych Zakładu Doświadczalnego PAN w Gołyszu. Prace te były kontynuacją prowadzonych badań na stawkach doświadczalnych, a ich celem było stwierdzenie wpływu na organizm ryb czynników towarzyszących intensyfikacji produkcji, takich jak: zagęszczenie ryb, zanieczyszczenie wody, żywienie paszami wysokobiałkowymi itp.

Badania obejmowały: kontrolę obecności pasożytów zewnętrznych i wewnętrznych (tabela III), analizę zmian anatomopatologicznych (tabela II) oraz wskaźników hematologicznych (ryc. 1, 2, 3), w skład których wchodziło oznaczanie zawartości hemoglobiny, hematokryt, analiza rozmazów oraz oznaczanie poziomu białka całkowitego w surowicy krwi.

Opierając się na uzyskanych wynikach można stwierdzić, że nie ma istotnych różnic w przeżywalności (tabela I) i kondycji między rybami pochodzącymi ze stawów o produkcji intensywnej (M, P_L, P_H), a ze stawów o tradycyjnym sposobie produkcji (T). Stosunkowo często obserwowano zmiany w obrębie aparatu skrzelowego. Występowały one u dużej części ryb ze wszystkich stawów, wykazując nieco odmienny przebieg u karpi ze stawów o gęstych obsadach. Uszkodzenia skrzeli powodowały zmniejszenie tolerancji na spadki zawartości tlenu w wodzie, niekiedy osłabienie ryb, zaniechanie pobierania paszy. Nie były one jednak przyczyną masowych śnięć karpi. Również nieco częściej u ryb pochodzących ze stawu o intensywnym poziomie produkcji występowały zmiany w obrębie narządów wewnętrznych. Polegały one zwykle na zmianach w wątrobie, zastojach żółci, obrzękach nerki wydalniczej. Stwierdzono, że zagęszczenie ryb ma wpływ zarówno na intensywność, jak i ekstensywność występ-

powania pasożytów. W analizowanym okresie jednak na każdym ze stawów pasożyty nie stworzyły zagrożenia dla produkcji rybackiej. Z wyjątkiem podwyższenia zawartości białka całkowitego w surowicy krwi, nie stwierdzono wyraźnego wpływu intensyfikacji produkcji na analizowane wskaźniki hematologiczne. U większości badanych karpi notowano spadki zawartości hemoglobiny we krwi. W krwi obwodowej obserwowano zwiększoną ilość niedojrzałych erytrocytów.

Pomimo stwierdzenia u wielu karpi, prawdopodobnie w efekcie działania niekorzystnych czynników towarzyszących intensyfikacji produkcji, zmian stanu zdrowotnego oraz, w mniejszym stopniu, analizowanych wskaźników fizjologicznych nasuwa się wniosek, że obecny poziom intensyfikacji nie stwarza istotnego zagrożenia dla ryb pod względem ichtiopatologicznym.

6. References

Amlacher E., 1972. Taschenbuch der Fischkrankheiten. Jena, G. Fischer Verl.

Blaxhall P. C., K. W. Daisley, 1973. Routine haematological methods for use with fish blood. J. Fish. Biol., 5, 771—781.

Golodyets G., 1954. Izmyenyenye sostava krovi molodykh ryb v svyazi s uslovyami vyraschivanya. Vopr. Ikhtiol., 2.

Ivanova Z. A., 1973. Pokazatyely krovi karpa *Cyprinus carpio* L. v ontogyenyezye i v zavisimosti ot uslovy vyrashchivanya. Vopr. Ikhtiol., 3, 495—507.

Kocyłowski B., T. Mączyński, 1960. Choroby ryb i raków [Fish and crab diseases]. Warszawa, PWRiL.

Kreutzmann H. L., 1974. Anleitung zur Durchführung routinemässiger Blutuntersuchungen an Fischen in der Praxis. Z. Binnenfisch. DDR, 21, 376—384.

Kudryashova J., 1969. Gyematologichyeskye pokazately u tseshuychtykh karpov vyrashchivanykh pri rozlichnom urovnye kormlyenya. Doklady TSChA, 151, 281—285.

Łysak A., 1959. Fish blood sampling for diagnostic investigations and its following influence on blood picture and growth rate. Acta Hydrobiol., 1, 37—54.

Łysak A., K. Wójcik, 1960. Electrophoretic investigations on the blood of carp fed with food containing various protein amounts. Acta Hydrobiol., 2, 49—61.

Markiewicz F., S. Hłond, K. Migała, J. Stefan, 1977. Nawożenie azotowo-fosforowe odgrodzonych części stawów. 7. Zdrowotność narybku [Fertilization of enclosed parts of ponds with nitrogen and phosphorus. 7. The health of carp fingerlings]. Roczn. Nauk Roln., H, 98, 1, 143—158.

Markiewicz F., J. Stefan, A. Pilarczyk, 1985. Studies on intensification of carp farming. 8. State of health and haematological indices of carp in experimental ponds. Acta Hydrobiol., 27, 219—228.

Migała K., 1970. Badania zewnętrznych pasożytów karpia w warunkach intensyfikowania produkcji stawowej. 1. *Protozoa* [Investigations on external parasites of carp reared in intensive ponds. 1. *Protozoa*]. Roczn. Nauk Roln., H, 92, 4, 49—72.

Pilarczyk A., 1977. Hematological and histological changes in carp with necrotic gill disease (branchionecrosis cyprinorum). Acta Hydrobiol., 19, 9—22.

Svobodová Z., J. Havelka, 1977. Research in the effect of intensifying practices on the health condition and some hematological indices of carp in one-year and two-year pond management system. Práce VURH, 10, 47—74.

Szumiec J., 1985a. Studies on intensification of carp farming. 1. Introduction and general programme. Acta Hydrobiol., 27, 131—145.

Szumiec J., 1985b. Studies on intensification of carp farming. 10. Productive results, environmental changes, and final considerations. Acta Hydrobiol., 27, 241—277.