

Biochemical and hematological parameters in European sea bass (*Dicentrarchus labrax* Linnaeus, 1758) and Gilthead sea bream (*Sparus aurata* Linnaeus, 1758) in relation to temperature

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ABSTRACT

In order to evaluate the influence of temperature on biochemical and hematological parameters in two different farmed fish, the gilthead sea bream (*Sparus aurata* Linnaeus, 1758) and the European sea bass (*Dicentrarchus labrax*, Linnaeus, 1758), blood samples were collected from a total of 60 specimens of each species, reared in Sicily, in the cold (February, mean temperature 13.40 °C) and warm seasons (October, mean temperature 23.20 °C). Biochemical (glucose, lactate, cholesterol, triglycerides and total protein) and hematological (red blood cell RBC, hemoglobin concentration Hgb, hematocrit Hct, mean corpuscular volume MCV, mean corpuscular hemoglobin MCH and mean corpuscular hemoglobin concentration MCHC) parameters were evaluated. Significant differences ($P < 0.05$) were observed for glucose, lactate, triglycerides, cholesterol, total protein and RBC, Hgb, Hct, MCV, and MCH. This information could be useful for optimization of the husbandry practices in land-based aquaculture, and provide useful information for monitoring changes in the health status of fish.

Key words: blood parameters; farmed fish; growth; season; water temperature

Introduction

In European marine aquaculture, European sea bass (*Dicentrarchus labrax* Linnaeus, 1758) represents a very important species. The natural populations have been widely

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exploited, therefore appropriate management and conservation measures are necessary. In both farming conditions and the natural environment, the reproduction of sea bass takes place in temperatures between 11 and 15 °C. The gilthead sea bream *Sparus aurata* (Linnaeus, 1758) is largely farmed around the Mediterranean area, and the main centers of its production are Turkey, Greece, Italy and Spain (PARISI et al., 2014).

Environmental stress alters homeostasis and influences biological functions (GRACEY et al., 2004). Physical and chemical processes within biological systems are strongly influenced by temperature (SCOTT and JOHNSTON 2012). Temperature is one of the common variables in the aquatic environment that directly affect the survival of marine organisms. Under culture conditions, fluctuations in water temperature governed by seasonal shifts affect the immune system and other physiological functions, such as growth efficiency through enzyme activity, and reproduction. However, sudden fluctuations in water temperature that exceed the threshold values often cause the death of fish (CHATTERJEE et al., 2004; CHENG et al., 2013). Some authors have indicated that species with similar thermal preferences may respond differently to the same sub-daily temperature fluctuations (COULTER et al., 2016). Fish farmers aim to improve fish welfare, to guarantee successful farming, and to mitigate disease outbreaks in aquaculture that cause substantial economic loss. Therefore it is necessary to develop control strategies based on a better understanding of the effects of environmental stressors on the health status of farmed fish (BOWDEN et al., 2007). The study of the hematological and biochemical parameters in cultured fish species is an important tool in the development of aquaculture systems (O'NEAL and WEIRICH, 2001; PERCIN and KONYALIOGLU, 2008; MAURI et al., 2011). These parameters provide information not only about the health status of fish and the water quality in which they live, but also help to foresee, at some level, the susceptibility of organisms to changes in environmental conditions (PERCIN et al., 2010; AYOOLA et al., 2011). The physiological and metabolic response of fish to environmental changes can be examined using hematological and biochemical parameters, because blood constituents respond rapidly to any factor that affects homeostasis, including the influences of the habitat (LOHNER et al., 2001, CAZENAVE et al., 2005; ELAHEE and BHAGWANT, 2007). Rapid temperature changes have the potential to dramatically affect physiological processes in aquatic organisms and, due to their limited mobility, fish in their early life stages are particularly vulnerable to ambient temperature fluctuations (COULTER et al., 2015). Previous research showed monthly variations of biochemical and hematological parameters in sea bream and sea bass reared in Mediterranean off-shore tanks (FAGGIO et al., 2014a, 2014 b). The aim of this study was to investigate biochemical (glucose, lactate, cholesterol, triglycerides and total protein) and hematological (red blood cell RBC, hemoglobin concentration Hgb, hematocrit Hct, mean corpuscular volume MCV, mean corpuscular hemoglobin MCH and mean corpuscular hemoglobin concentration MCHC) parameters, and growth indices

(weight, length, viscero-somatic index VSI and condition factor CF) in *S. aurata* and *D. labrax* during two different seasons (the warm period in October, 23.20 °C and the cold period in February, 13.40 °C) in order to evaluate the effect of temperature.

Materials and methods

The study was conducted by collecting a total of 120 fish: 60 *Sparus aurata* (144.62 ± 13.49 g weight; 19.58 ± 0.93 cm length) and 60 *Dicentrarchus labrax* (142.24 ± 11.82 g weight; 19.09 ± 0.55 cm length) from a Sicilian fish farm. Fish, reared in land-based outside tanks (210 m³) in an open aquaculture system with a continuous supply of sea water, were subjected to natural environmental conditions (photoperiod and water temperature); stocking density was 31 kg.m⁻³ for sea bass and 36 kg.m⁻³ for sea bream.

The fish were fed twice (9:00; 18:00) every day, equally in the two periods, with a commercial diet specific for the two species, containing different levels of protein and lipid (47/20% for sea bream and 45/20% for sea bass respectively) (Skretting Italia. SpA, Mozzecane, Verona, Italia).

Table 1. Environmental parameters recorded in the aquaculture implant during the two sampling season

Month	Photoperiod (L/D)	Temperature (°C)	Dissolved oxygen (mg/dL)
October	13/11	23.20 ± 0.22	3.8 ± 0.05
February	12/12	13.40 ± 0.18	5.6 ± 0.07

On the basis of the environmental recordings from the previous year, it was decided to sample the fish at the periods' extreme water parameters; the warmest time, in October (mean temperature 23.20 ± 0.22 °C) and the coldest time, in February (mean temperature 13.40 ± 0.18 °C). On the farm, water temperature and dissolved oxygen were tested five times at 8.00 a.m. in October and five times in February, at a depth of two meters. Table 1 shows the environmental parameters recorded in the aquaculture implant during the two sampling season. All fish were considered clinically healthy on the basis of an external examination for any signs of abnormalities or infestation, came from the two different production batches on the same farm and were kept in two different tanks with similar biometric indices (Table 2). Fish were randomly sampled before feeding from the same batch, by confinement and netting in the tanks. The fish were anaesthetized prior to blood sampling using 2-Phenoxyethanol (99%, MERCK, Whitehouse Station, NJ, USA) at a concentration of 400 ppm. Immediately after the anaesthetization procedure, the fish were individually weighed to the nearest 0.01g (Mark 2200, BEL Engineering Srl, Monza), their fork length (*L*) was recorded and finally they underwent venipuncture. At the end of the blood sampling, visceral weight (*W_v*), including liver, spleen, pancreas and intestines) was recorded. Growth performance was assessed using condition factor (CF), and the viscero-somatic index (VSI), as reported in Table 2.

For each season, CF was calculated as:

$W \times 100 L^{-3}$, where W is the weight of animal and L is the length;

VSI was calculated as:

$W_v \times 100/W$, where W_v is the visceral weight and W wet weight.

Table 2. Parameters useful to assess growth performance of *S. aurata* (n = 30 each month) and *D. labrax* (n = 30 each month): condition factor (CF) and viscero-somatic index (VSI). Sample obtained on two different production batches

Months		Weight (g)	Visceral weight (g)	Fork length (cm)	VSI	CF
October 2013	<i>S. aurata</i>	145.40 ± 12.96	11.62 ± 1.77	19.78 ± 0.91	7.99	1.91
	<i>D. labrax</i>	142.52 ± 11.05	13.34 ± 1.77	19.38 ± 0.99	7.96	1.98
February 2014	<i>S. aurata</i>	143.84 ± 14.02	11.26 ± 2.10	19.38 ± 0.96	7.81	2.01
	<i>D. labrax</i>	141.97 ± 12.59	10.90 ± 2.00	18.80 ± 1.12	7.68	2.18

Blood samples were obtained from the caudal vein using a 20 G×1½ syringe, and were collected in two tube types: microtubes (Miniplast 0.6 mL, LP Italiana Spa, Milano) containing EDTA (ratio 1.26 mg/0.6 mL) as the anticoagulant agent to assess Red Blood (RBC), Hematocrit (Hct), Hemoglobin concentration (Hgb), Mean Corpuscular Volume (MCV), Mean Corpuscular Haemoglobin (MCH) and Mean Corpuscular Haemoglobin Concentration (MCHC); and non-heparinised tubes to test serum total protein, cholesterol and triglycerides. For assessment of glucose and lactate in the whole blood, portable blood glucose (ACCU-Chek Active, Roche Diagnostics GmbH, Mannheim, Germany) and portable blood lactate analyzers (Accusport, Boehringer Mannheim, Germany) were used.

The time elapsing from capture to blood collecting was less than 5 min. To assess RBC, Hgb, Hct, MCV, MCH, MCHC values, a blood cell counter HeCo Vet C (SEAC, Florence, Italy) was used. As previously described in *S. aurata* (FAZIO et al. 2012; 2013). Falcon tubes were centrifuged at room temperature at 1300g for 10 min and the obtained serum was stored at -20 °C and analyzed 20 days later. The concentrations of serum total proteins (TP), cholesterol and triglycerides were determined by means of commercial kits (SEAC, Florence, Italy) using an automated UV Spectrophotometer (SEAC, Slim, Florence, Italy).

All samples were analyzed in triplicate by the same operator. The samples exhibited parallel displacement to the standard curve. The overall intra-assay coefficient of variation was <5%. The protocols of animal husbandry and experimentation were reviewed and approved in accordance with the standards recommended by the Guide for the Care and Use of Laboratory Animals, and Directive 2010/63/EU for animal experiments.

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Statistical analysis. Blood parameters and the biometric index were compared between seasons (warm temperature vs. cold temperature) in both species using the t-test; when the assumption of homogeneity of variance was not met, the Welch test was used. Results were considered significant at a P-value less than 0.05 and were verified with the Monte Carlo method (with 10.000 samples). Furthermore, Pearson's correlation analysis was utilized for each species of fish separately to calculate the correlations of the blood parameters in the two different water temperatures (Tables 3 and 4).

Table 3. Correlation matrix among the hematological and biochemical parameters of *Sparus aurata* (Linnaeus, 1758) in warm and cold water

	Water	RBC	Hgb	Hct	MCV	MCH	MCHC	GLU	LAC	TRIG	CHOL	TP
RBC	warm	-										
	cold	-										
Hgb	warm		-									
	cold	0.556**	-									
Hct	warm			-								
	cold	0.462*		-								
MCV	warm	-0.896**	0.462*		-							
	cold	-0.788**			-							
MCH	warm	-0.717**		0.483**	0.639**	-						
	cold	-0.602**		0.423*	0.477**	-						
MCHC	warm		0.535**	-0.873**	0.421*	-0.422*	-					
	cold		0.390*	-0.745**	0.406*	-0.604**	-					
GLU	warm			0.405*			0.438*	-				
	cold							-				
LAC	warm								-			
	cold								-			
TRIG	warm	-0.400*								-		
	cold									-		
CHOL	warm										-	
	cold	0.535*			-0.562**	-0.533**		0.417*			-	
TP	warm											-
	cold							-0.370*				-

*Correlation is significant for $P < 0.05$; **Correlation is significant for $P < 0.01$; Red blood cell (RBC); Haemoglobin concentration (Hgb); Haematocrit (Hct); Mean corpuscular volume (MCV); Mean corpuscular haemoglobin (MCH); Mean corpuscular haemoglobin concentration (MCHC); Glucose (GLU); Lactate (LAC); Triglycerides (TRIG); Cholesterol (CHOL); Serum total proteins (TP)

Table 4. Correlation matrix among the hematological and biochemical parameters of *Dicentrarchus labrax* (Linnaeus, 1758) in warm and cold water

	Water	RBC	Hgb	Hct	MCV	MCH	MCHC	GLU	LAC	TRIG	CHOL	TP
RBC	warm	-										
	cold	-										
Hgb	warm		-									
	cold	0.556**	-									
Hct	warm			-								
	cold	0.462*		-								
MCV	warm	-0.896**	0.462*		-							
	cold	-0.788**			-							
MCH	warm	-0.717**		0.483**	0.639**	-						
	cold	-0.602**		0.423*	0.477**	-						
MCHC	warm		0.535**	-0.873**	0.421*	-0.422*	-					
	cold		0.390*	-0.745**	0.406*	-0.604**	-					
GLU	warm			0.405*			0.438*	-				
	cold							-				
LAC	warm								-			
	cold								-			
TRIG	warm	-0.400*								-		
	cold									-		
CHOL	warm										-	
	cold	0.535*			-0.562**	-0.533**		0.417*			-	
TP	warm											-
	cold							-0.370*				-

*Correlation is significant for $P < 0.05$; **Correlation is significant for $P < 0.01$; Red blood cell (RBC); Haemoglobin concentration (Hgb); Haematocrit (Hct), Mean corpuscular volume (MCV); Mean corpuscular haemoglobin (MCH); Mean corpuscular haemoglobin concentration (MCHC); Glucose (GLU); Lactate (LAC); Triglycerides (TRIG); Cholesterol (CHOL); Serum total proteins (TP).

All calculations were performed using the R statistical language package, ver. 2.13.

Results

The unpaired *t*-test did not show any significant differences in biometric indices during the sampling periods (Table 2). In both species the unpaired *t*-test showed significant changes in all parameters except MCHC. Lactate, triglycerides, Hgb, Hct, MCV and MCH values showed the same trends in both species, while glucose, cholesterol, total protein, RBC and MCHC values displayed different trends between the two species. Mean values and standard deviations, with statistical differences between the times of sampling (warm

vs. cold) and the percentage of variation recorded in all parameters evaluated in *S. aurata* and *D. labrax*, are reported in Table 5.

Table 5. Mean values and standard deviations together the statistical differences between the times of sampling (warm vs cold) and percent changes variation recorded in all parameters studied in *Sparus aurata* (Linnaeus, 1758) and *Dicentrarchus labrax* (Linnaeus, 1758)

Parameters	<i>S. aurata</i>			<i>D. labrax</i>		
	Warm	Cold	Percent change	Warm	Cold	Percent change
Glucose (mg/dL)	109.30 ± 12.16*	244.50 ± 12.96	124%	217.60 ± 25.74*	181.90 ± 30.85	-16.40%
Lactate (mmol/L)	9.27 ± 0.92*	3.46 ± 0.57	-62.64%	17.98 ± 2.29*	11.02 ± 1.44	-38.71%
Triglycerides (g/dL)	211.00 ± 35.28*	333.70 ± 32.52	58.15%	318.40 ± 21.56*	565.70 ± 75.13	77.67%
Cholesterol (g/dL)	231.50 ± 24.14*	251.00 ± 15.57	8.42%	222.20 ± 26.66	209.70 ± 22.51	-5.63%
Total Protein (g/dL)	4.33 ± 0.49*	3.42 ± 0.38	-21.1%	3.73 ± 0.29*	4.08 ± 0.79	9.38%
RBC (×10 ¹² /L)	3.48 ± 0.51*	2.90 ± 0.31	-16.65%	3.02 ± 0.66*	4.01 ± 0.60	32.92%
Hgb (g/dL)	9.62 ± 0.74*	10.26 ± 0.67	6.68%	6.67 ± 0.87*	10.60 ± 1.10	58.92%
Hct (%)	42.58 ± 5.12*	46.62 ± 4.27	9.48%	32.00 ± 3.48*	48.38 ± 4.81	51.18%
MCV (fL)	124.50 ± 20.22*	161.90 ± 16.14	30.04%	109.40 ± 18.83*	122.20 ± 14.66	11.70%
MCH (pg)	28.26 ± 4.77*	35.65 ± 3.03	26.15%	23.28 ± 6.60*	26.82 ± 3.62	-15.20%
MCHC (g/dL)	22.91 ± 3.22	22.14 ± 2.02	-3.36%	21.07 ± 3.41	21.96 ± 1.53	4.20%

*Warm vs Cold (P<0.05); Red blood cell (RBC); Haemoglobin concentration (Hgb); Haematocrit (Hct); Mean corpuscular volume (MCV); Mean corpuscular haemoglobin (MCH); Mean corpuscular haemoglobin concentration (MCHC).

Some of the biochemical and hematological parameters obtained from *S. aurata* (n = 60) and *D. labrax* respectively (n = 60) were significantly correlated in the two different experimental periods (warm and cold water temperature) (Tables 3 and 4).

Discussion

Our data showed a variation of biochemical and hematological parameters in relation to two different water temperatures. Temperature is one of the common variables in the aquatic environment that influence oxygen solubility in water (CECH and BRAUNER, 2011), and hence fish must respond by changing their blood parameters.

Under culture conditions, fluctuations in water temperature affect the blood, and sudden fluctuations in water temperature that exceed the threshold values often cause the death of fish (CHATTERJEE et al., 2004; CHENG et al., 2013). Hematological parameters are likely to change according to the changes in the aquatic environment; they can help us to understand the process of adaptation of animals to their environment (RANZANI-PAIVA et al., 2005), and provide references to identify any changes in the condition of the fish's health.

Changes in the hematological and biochemical responses to water temperature have been studied in rainbow trout (*Oncorhynchus mykiss*), goldfish (*Carassius auratus*), Atlantic cod (*Gadus morhua*), tilapia (*Oreochromis mossambicus*), olive flounder (*Paralichthys olivaceus*) and silver catfish (*Schilbe Intermedius*) (BASU et al., 2001; LERMEN et al., 2004; YANG and YEO, 2004; GOLLOCK et al., 2006; HUR and HABIBI, 2007; JEONG et al., 2012).

S. aurata from this study showed higher RBC during the warm period, probably due to the fact that more cells are required to carry oxygen around the body of fish when the solubility of oxygen is low (STOLEN et al., 1984; PASCOLI et al., 2011). Some authors (ADEYEMO et al., 2009; MIREA et al., 2013) observed similar results in *Clarius gariepinus*. The increased RBC count may be due to stimulation of erythropoietin by elevated demands for O₂. The increase in red blood cells was associated with a decrease in Hct and Hgb, as observed by MIREA (2013) in Nile tilapia (*Oreochromis niloticus*) who were subjected to different water temperatures.

Different fish species show different changes in their hematology after exposure to an increase in water temperature. *D. labrax* showed higher RBC in a cold water temperature, and this may suggest that, in this species, hematological parameters might have been affected by the photoperiod rather than the temperature (SOLOMON and OKOMODA, 2012). An increase in the total number of circulating erythrocytes causes the parallel increases in Hct and Hgb. The influence of different photoperiods on hematological parameters has been shown in previous research on *Clarias Gariepinus* reared in a water recirculation system (SOLOMON and OKOMODA, 2012).

Studies relating to the influence of the photoperiod on hematological parameters in fishes are rather few and the responses observed are quite variable (SRIVASTAVA and CHOUDHARY SANJEEV, 2010).

The temperature of the aquatic environment is important for the survival, distribution and normal metabolism of fish; failure to adapt to temperature fluctuations is generally ascribed to the inability of fish to respond physiologically, with resultant mortality, which is related to changes in their metabolic pathways (ADEYEMO et al., 2003).

Biochemical profile is a good indicator of metabolic adjustment during acclimation to seasonal variations in sea bream (FAGGIO et al., 2014b). Biochemical responses in farmed fish subject to different temperatures are generally measured using reliable parameters, such as glucose, lactate and lipids. An increased water temperature enhanced carbohydrate utilization and liver glycolytic, gluconeogenic and lipogenic capabilities in gilthead sea bream, *Sparus aurata* (ENES et al., 2006, 2008a; COUTO et al., 2008) and European sea bass, *Dicentrarchus labrax* (ENES et al., 2008b; MOREIRA et al., 2008). This research is in accordance with our data obtained in *Sparus aurata*, where we showed an increase in blood glucose in a cold temperature. Some authors (TUNG and SHIAU, 1991) showed that plasma glucose levels in rainbow trout were higher at a water temperature of 8 °C, than at 18 °C. Higher temperatures would promote glucose absorption into cells (HEMRE et al., 2002). In contrast to observations in sea bream, a significant increase in glucose level was noted in our study for *D. labrax* during warm months, but this result is not supported by the literature data. Physiological responses in teleost fish that are subject to water temperature changes are generally measured using reliable parameters such as glucose, lactate and lipids (VARGAS-CHACOFF et al., 2009; KYPRIANOU et al., 2010). In grass carp and milkfish, exposure to cold causes a rapid increase in glucose levels that afterwards return to the normal range within 2 days (KUO and HSIEH, 2006). In milkfish, changes in fatty acid and glucose metabolism have been shown following exposure to hypothermia (HSIEH et al., 2003; KUO and HSIEH, 2006).

At temperatures below 14 °C, a high blood glucose level is an index of sub-lethal stress and also indicates a retarded metabolism (BEST et al., 2001). Silver catfish *Clarias batrachus*, stores glucose under cold conditions, resulting in gluconeogenesis, whereas in warm water, it probably consumes glucose. LERMEN et al. (2004) reported that its serum glucose level increased with the fall of temperature. Moreover, the highest blood glucose level was observed in the winter and the lowest during the summer, and correlated to the lowering of the temperature.

The higher level of blood lactate found during the warm months in both species in this study, may be due to the lower level of dissolved oxygen in the water, and the consequent activation of their anaerobic metabolism (OMLIN and WEBER, 2010). When gilthead sea bream is maintained at a critically low temperature, the increase in LDH activity and the accumulation of tissue lactate indicate that hypothermia has stimulated the anaerobic metabolism (KYPRIANOU et al., 2010). These results suggest that production of blood lactate may be greater at warmer temperatures, as the release rate is dependent

on temperature and the clearance rate is inversely related to it. The lower values showed in colder months is probably due to the oxidation of lactate when oxygen is plenty.

Fish are able to adapt to cold temperatures by changes in their lipid metabolism. Cold treatment in fish, influencing signal transduction, may change the expression of genes associated with lipid metabolism which mainly includes lipid transport, steroid biosynthesis, and glycerol phospholipid biosynthesis (HU et al., 2014). The fluidity of the membranes may be optimized by these changes in the lipid composition at cold temperatures, they may also affect the activity of membrane proteins. Our results showed an increase in lipid composition (cholesterol and triglycerides) in sea bream in colder months. This could be related to the metabolism becoming slower. In many fish species, enhanced lipogenesis is observed at colder temperatures. SHIKATA et al. (1995) reported that fatty acid synthesis from amino acids is elevated with cold acclimation in carp livers. Fats are the fatty acid esters of glycerol and represent the primary energy depots of animals. These are used for long-term energy requirements during periods of inadequate food and energy intake. Another possible explanation for increased serum total cholesterol is endocrine system regulation; cholesterol is the precursor of various steroid hormones (corticosteroid), in particular those involved in physiological adjustments (PANKHURST, 2011).

The increase in plasma protein concentrations is indicative of fluid moving out of the extracellular spaces into the white muscle (WANG et al., 1994), or water moving out of the fish itself, and suggests stress associated with higher temperatures and the consequent higher swimming activity in *S. aurata*. Our data also showed a significant correlation between the hematological and biochemical parameters of the two species in the two different experimental periods (warm and cold water temperature).

The biometric indices we studied in *S. aurata* and *D. labrax* during two different seasons showed no statistically significant differences (Table 2). Despite the fact that in both species temperature influences some biochemical parameters (glucose, lactate, triglycerides, cholesterol and total protein) closely related to the metabolism and growth, we did not observe variations in the biometric indexes of species studied during the two different seasons. The temperature variations related to the recorded values do not seem to be a factor negatively associated with reproductive performance.

If $CF < 1.0$ the fish is in poor condition and if $CF > 1.4$ the fish is in good to excellent condition. Our results showed that this factor was always > 1 , so seasonal variations do not compromise the welfare status of either species in our study.

Blood parameters are potentially related to the changes in water temperature, and are highly dependent on seasonal variability. However several other abiotic characteristics of the water environment may also play a part.

This study represents an experimental model applied to species farmed in aquaculture and might also be useful for any advance study concerning the acclimation mechanism. The current study will be of help to aquaculture officials responsible for future decisions in the managing and rearing of fish used for human consumption. Further research should be conducted on other species monitored in the natural environment in different seasons, in order to optimize husbandry practices.

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Conflicts of interest

The authors declare that they have no conflict of interest.

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FAZIO, F., V. FERRANTELLI, G. PICCIONE, C. SAOCA, M. LEVANTI, M. MUCCIARDI: Biokemijski i hematološki pokazatelji lubina (*Dicentrarchus labrax* Linnaeus, 1758.) i komarče (*Sparus aurata* Linnaeus, 1758.) u odnosu na temperaturu. *Vet. arhiv* 88, 397-411, 2018.

SAŽETAK

Cilj istraživanja bio je procijeniti utjecaj temperature vode na biokemijske i hematološke pokazatelje kod dvije različite vrste farmски uzgajanih riba: lubina (*Dicentrarchus labrax* Linnaeus, 1758.) i komarče (*Sparus aurata* Linnaeus, 1758.). Ukupno 60 uzoraka krvi prikupljeno je od svake vrste, uzgajane na Siciliji, tijekom hladne (veljača, srednja temperatura 13,40 °C) i tople (listopad, srednja temperatura 23,20 °C) sezone. Analizirani su biokemijski pokazatelji (glukoza, laktat, kolesterol, trigliceridi i ukupne bjelančevine) i hematološki pokazatelji (broj eritrocita, koncentracija hemoglobina, hematokrit, prosječni volumen eritrocita MCV, prosječni hemoglobin u eritrocitu MCH i prosječna koncentracija hemoglobina u eritrocitu MCHC). Značajne razlike ($P < 0,05$) zabilježene su za glukozu, laktat, trigliceride, kolesterol i ukupne bjelančevine te za broj eritrocita, koncentraciju hemoglobina, hematokrit, MCV i MCH. Informacije utvrđene ovim istraživanjem mogle bi biti korisne za optimalnu uzgojnu praksu u akvakulturi kao i za praćenje promjena u zdravstvenom statusu riba.

Ključne riječi: krvni pokazatelji, farmски uzgoj riba; rast; sezona; temperatura vode
