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Body features and growth dynamics of two rainbow trout (*Oncorhynchus mykiss*) varieties, Irideus vs. Palomino

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Abstract. Due to diversification of salmonid species which are farmed in Romania, the aim of this study was been to determine the production performances of rainbow trout (*Oncorhynchus mykiss*), Palomino variety, compared with the clasical variety – Irideus. Analyzing the body weight of both varieties at the end of experiment, was recorded a very significant differences (d=16.11 g; p<0.001) in favor of the irideus Variety. Also, very significant differences was recorded regarding other morphological characters (Tl-d=0.93 cm, p<0.001; Sl-d=0.88 cm, p<0.001; Cl-d=1.07 cm, p<0.001), favorable for Irideus variety. Growth indices showed also favorable values for Irideus variety (TG:d=16.05 g, p<0.001; ADG:d=0.041 g, p<0.05). Regarding the body form indices, the differences between the two varieties were generally insignificant, except Fullton Condition Factor (K:d=0.06; p<0.001), this presenting favorable values for Palomino variety, respectively Meat indices 2 (Mi2:d=0.44; p<0.05), being favorable for Irideus variety.
Key Words: Rainbow trout, salmonids, body features, growth dynamics.

Rezumat. În urma diversificării speciilor de salmonide exploatate în România, scopul prezentului studiu a fost acela de a determina performanţele de producţie a păstrăvului curcubeu (*Oncorhynchus mykiss*) varietatea Palomino, comparativ cu varietatea clasică – Irideus. Analizând greutatea corporală a celor două varietăţi la sfârşitul experimentului, a fost înregistrată o diferenţă foarte semnificativă (d=16.11 g; p<0.001) în favoarea varietăţii Irideus. De asemenea, au fost înregistrate diferenţe foarte semnificative şi în ceea ce priveşte alte caractere morfologice (Lt-d=0.93 cm, p<0.001; Ls-d=0.88 cm, p<0.001; Lc-d=1.07 cm, p<0.001), tot în favoarea varietăţii Irideus. Indicii de creştere au prezentat valori de asemenea în favoarea varietăţii Irideus (ST:d=16.05 g, p<0.001; SMZ:d=0.041 g, p<0.05). În ceea ce priveşte indicii de format corporal, diferenţele înregistrate între cele două varietăţi au fost în general nesemnificative, cu excepţia Factorului de condiţie Fulton (K:d=0.06; p<0.001) care a prezentat valori favorabile pentru varietatea Palomino, respectiv Indicele de carnozitate 2 (Ic2:d=0.44; p<0.05), acesta fiind în favoarea varietăţii Irideus.
Cuvinte cheie: Păstrăv curcubeu, salmonide, însuşiri de conformaţie, dinamica de creştere.

Introduction. Salmon farming is one of the most important branches in fish farming (Gabor et al 2012). Today, the Romanian farm trout culture is trying to align with international standards. Among the measures taken in this way is the increasing species diversity exploited in captivity. Recently it was introduced in some of the trout farms in Romania, a new variety of rainbow trout (*Oncorhynchus mykiss*), the Palomino golden trout, named after its golden-yellow colour. The Palomino golden trout is the result of multiple selections and crosses between classic rainbow trout individuals (Dobosz et al 2000). For the first time, they were obtained in West Virginia, USA (Dobosz 2007). This is not a sterile hybrid, being just a golden-yallow coloured variety (Galbreath & Plemmons 2000). The Palomino golden trout, should not be mistaken with another subspecies of rainbow trout, such as golden trout (*Oncorhynchus mykiss aguabonita*), which is a native from Californian mountain waters, or Mexican golden trout (*Oncorhynchus chrysogaster*), widespread in northern Mexico (Rio Fuerte) (Moyle et al 1995; Behnke 2002). Regarding intensive farming of rainbow trout (Palomino variety), there are numerous farms both

on the North American continent and Europe. Usually, this variety is being exploited in simple culture, but there are common situations in which it is grown in polyculture along other salmonid species, especially with classical rainbow trout (Irideus variety). In the present study, we aimed to analyze the production performances and body features of the Palomino variety, compared to the Irideus variety, in environmental conditions from Gilău trout farm, Cluj County. Both varieties are farmed together in the same ponds (www.pastravariagilau.ro). To do this, we monitored environmental specific parameters were the experiment took place; it is followed the growth dynamics of the biological material, expressed by growth indices. So far, there is no known data on the dynamics and growth indices of the Palomino variety in Romania, therefore we consider our researches as pioneering representing points of originality of this study.

Material and Method. Experiments were conducted between March 2011 and April 2012, at Gilău trout farm, Cluj County. Measurements, weighings and the observations necessary in the present study, were made onsite in farm. Also, were monitored onsite physico-chemical parameters of ponds water. Were didn't organize any experimental groups. The individuals taken for study were collected randomly from the entire group of the trout production cycle at Gilău farm. Both varieties (Figure 1) were exploited in polyculture, in the same ponds.

Figure 1. The two varieties of rainbow trout (*Oncorhynchus mykiss*): a-Irideus variety; b-Palomino variety (original photography).

Food used throughout the production cycle were manufactured by Skretting. Feeding has been made according to the manufacturer's specification, as shown in tables 1 and 2.

Table 1

Skretting Classic Extra – chemical composition of growth fodder

Granulation (Ø)	*2.50 mm 1P*	*4.00 mm 2P*	*6.00 mm 3P*	*6.00 mm 3P*
Crude protein %	41.00	41.00	41.00	41.00
Crude fat %	12.00	12.00	12.00	12.00
Cellulose %	3.00	3.00	3.00	3.00
Ash %	6.50	6.50	6.50	6.50
Phosphorus %	0.90	0.90	0.90	0.90
Digestible energy (MJ/kg)	14.20	14.20	14.20	14.20
Vitamin A (UI)	10.000	10.000	10.000	10.000
Vitamin D_3 (UI)	1.250	1.250	1.250	1.250
Vitamin E (mg)	150	150	150	150
Vitamin C (mg)	75	75	75	75
Lysine %	2.40	2.40	2.40	2.40
Methionine %	0.75	0.75	0.75	0.75
Cystine %	0.60	0.60	0.60	0.60

Ingredients: fish meal, fish oil, hemoglobin, soybean meal, soybean oil, wheat gluten, sunflower meal, wheat and wheat products, BHT.

Table 2

Feeding schedule for Skretting Classic Extra – growth fodder

Classic Extra	*Ø (mm)*	*Bw (g)**	*< 6° C*	*6° C*	*8° C*	*10°C*	*12°C*	*14°C*	*16°C*	*18°C*	*>18°C*
1P	2.50	12 – 100	**	1.0	1.2	1.4	1.7	1.9	2.0	1.6	***
2P	4.00	80 – 200	**	0.8	1.1	1.2	1.5	1.8	1.9	1.4	***
3P	6.00	170 – 400	**	0.7	0.9	1.1	1.4	1.7	1.8	1.3	***
3P	6.00	> 400	**	0.4	0.7	1.1	1.3	1.4	1.3	1.0	***

*Bw – Individual body weight of fish; ** The aim will be feeding activity of fish (appetite); *** Feeding depending on the level of dissolved oxygen; **** Under 4° C and over 20° C, fish feed only when needed.

Physico-chemical parameters of the water were monitored daily using Hanna HI 9828 Multiparameter. To determine the phenotypic characteristics of rainbow trout, the dynamics and growth indices were performed gravimetric and somatic measurements, being studied 11 morphological characters, according to the literature (Bud & Vlădău 2004; Grozea 2007). To determine body features we used Anderson & Neumann (1996) methods, by applying the data that we obtained in our previous studies, in equations of the reminded authors. The results were statistically analyzed using Microsoft Excel software, IBM SPSS and GraphPad InStat.

Results and Discussion. Food used throughout the production cycle was manufactured by Skretting, and imported into Romania by the Romavet Company. Food distribution was made according to the manufacturer's specifications.

As can bee seen in figure 2, average annual water temperature was between 1° C in february and 15° C in august. Due to thermal stratification of the water supply from Gilău Lake, the trout farm had very good climatic conditions between May and November, when water temperatures was above 10° C.

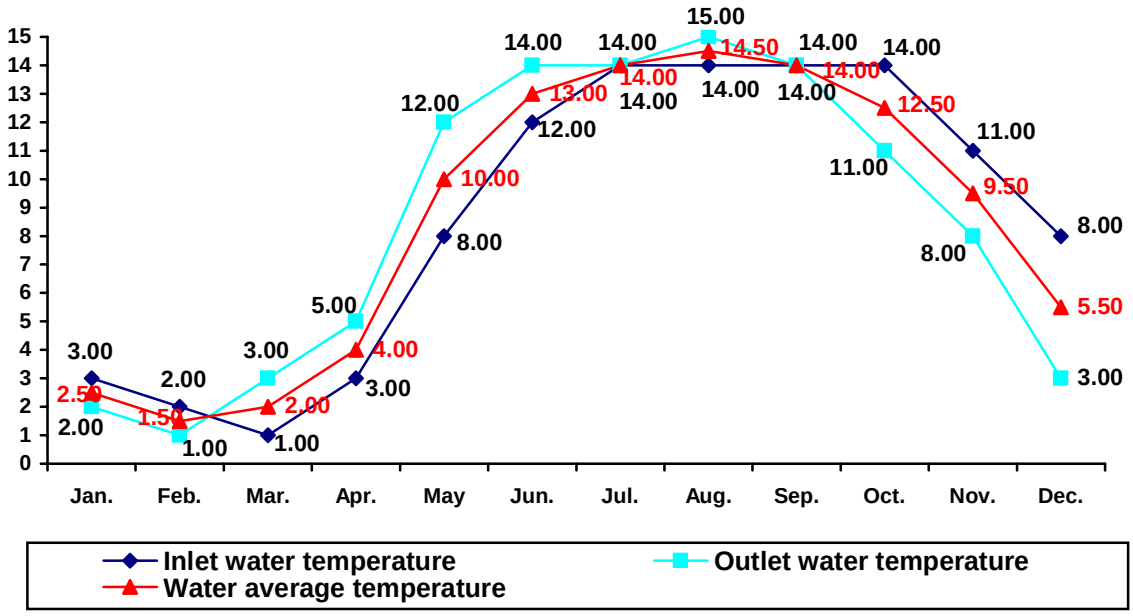

Figure 2. Monthly average water temperatures in Gilău trout farm.

This thermal stratification prevents water from freezing in the winter and no excessive increase in summer temperatures. Because of the inverse relationship with temperature, as shown in figure 3, the dissolved oxygen in water, decreases slightly during the summer when on average temperature of the water of 14.5° C in august, we recorded 8.25 mg/L dissolved oxygen. This value is according to biological requirements of rainbow trout.

Moreover, the dissolved oxygen level was within normal limits throughout our study, regardless of season or place of measurement (supply-exhaust). The highest values of dissolved oxygen in water were recorded in winter, when the average temperature of only 1.50° C corresponded to 9.65 mg/L dissolved oxygen. Differences of the level of dissolved oxygen were recorded between inlet and outlet of the water. This is due to oxygen consumption by fish material, and eliminates feces, uneaten food and entered into decay. Even so, high flow supply of trout farm permit the strong aeration, maintaining physical-chemical parameters within normal limits.

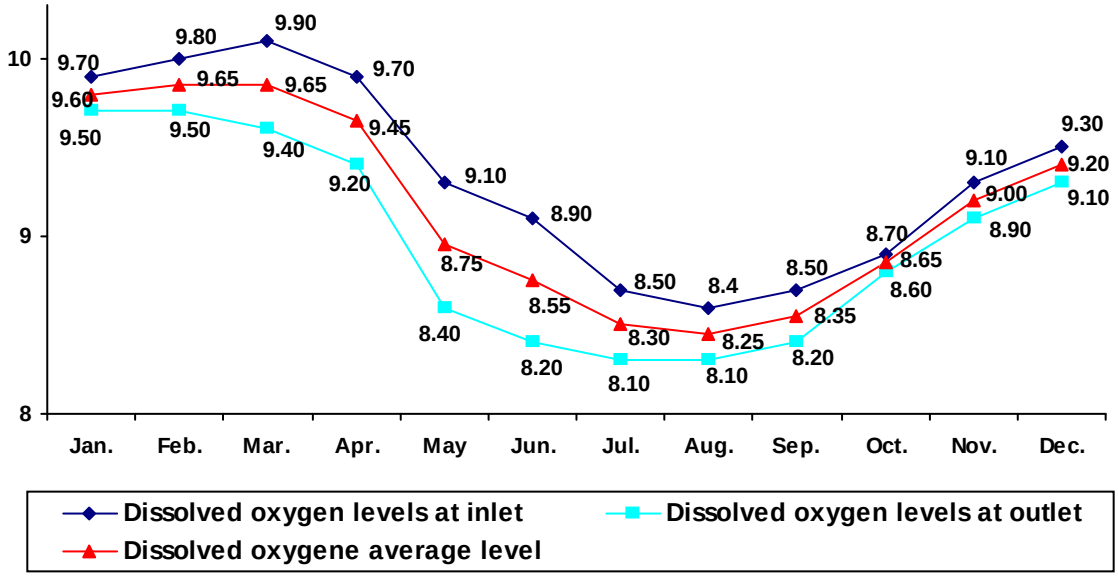

Figure 3. Monthly average values of dissolved oxygen at Gilău trout farm.

Process flow running in a trout farm can be influenced (positively or negatively) by the chemical reaction of water (pH), due to its concentration of hydrogen ions (Figure 4).

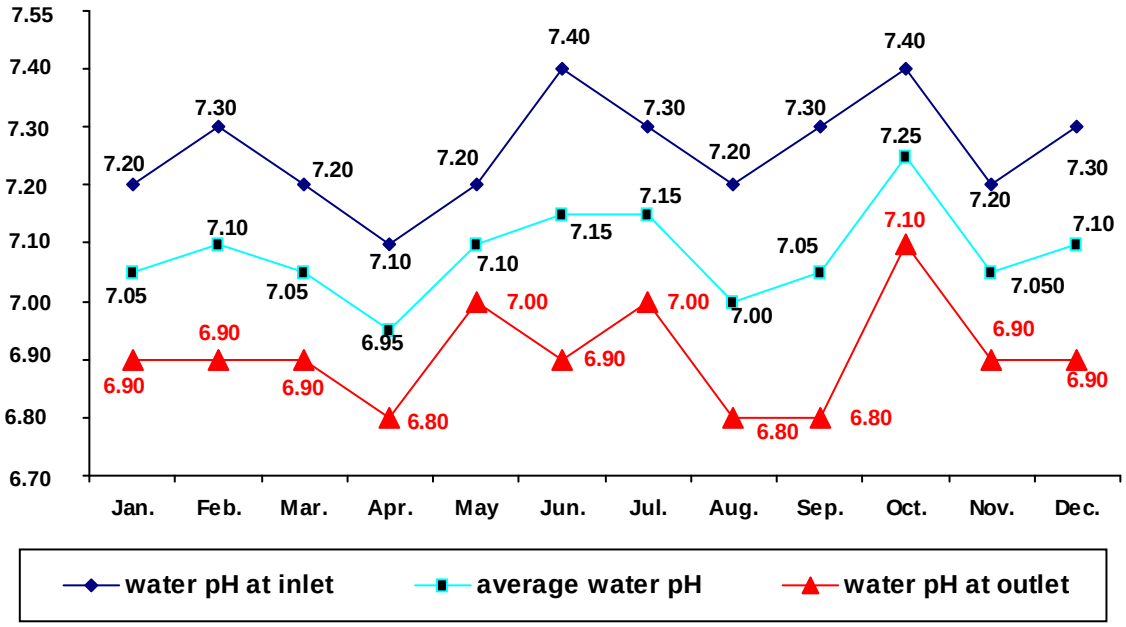

Figure 4. Water pH monthly average values at Gilău trout farm.

Depending on the ratio of acidic and basic components of the aquatic environment, water can be neutral (stable), acidic or alkaline. Improving water acidic or alkaline reaction is by increasing the water flow, which will dilute the concentration of acid or alkaline until the optimum is reached. In a trout farm, minimum and maximum limits regarding pH water is between 5.5 and 9. Optimum pH values are between 6.5 and 7.5. The average pH values in Gilău trout farm are optimal for salmonid rearing, ranging from 6.96 (April) and 7.25 (October). Lower values of water pH were recorded in the drain system. Slightly lower values of pH in the drain water are due to metabolites excreted by fish material exploited and entered into decaying uneaten food. Even under these conditions, the pH values are in accordance with the biological requirements of rainbow trout, because the Gilău Lake, is supplying with water the trout farm. This lake has a volume of water large enough so that the physico-chemical parameters present no great variations from one season to another.

In table 3 are shown the differences between the two varieties of rainbow trout (Irideus vs. Palomino), regarding the main gravimetric and somatic measurements at the end of the experiment.

Table 3

The statistical significance of the differences between the two varieties of rainbow trout (*Oncorhynchus mykiss*), regarding measurements

Specification	*Units*	*n*	*Group*	*Variables*				
				$\overline{X} \pm s_{\overline{X}}$	*V%*	*s*	*d*	*semnif*
Body weight (Bw)	g	50	I	284.77 ± 4.67	16.42	46.74	16.11	p<0.001
			P	268.66 ± 3.38	12.58	33.81	ooo	
Total length (Tl)	cm	50	I	28.48 ± 0.18	6.51	1.85	0.93	p<0.001
			P	27.55 ± 0.16	5.65	1.56	ooo	
Standard length (Sl)	cm	50	I	25.97 ± 0.17	6.55	1.70	0.88	p<0.001
			P	25.09 ± 0.14	5.49	1.38	ooo	
Commercial length (Cl)	cm	50	I	20.70 ± 0.16	7.88	1.63	1.07	p<0.001
			P	19.63 ± 0.11	5.83	1.14	ooo	
Maximum height (H)	cm	50	I	7.19 ± 0.05	6.83	0.49	0.20	p<0.05
			P	6.99 ± 0.04	6.00	0.42	o	
Minimum height (h)	cm	50	I	2.74 ± 0.02	8.57	0.23	0.07	p>0.05
			P	2.67 ± 0.02	7.28	0.20	ns	
Body depth (Bd)	cm	50	I	4.22 ± 0.04	10.49	0.44	0.15	p>0.05
			P	4.07 ± 0.05	11.53	0.47	ns	
Large perimeter (P)	cm	50	I	20.21 ± 0.19	9.25	1.87	0.89	p<0.05
			P	19.32 ± 0.21	10.66	2.06	o	
Small perimeter (p)	cm	50	I	6.92 ± 0.07	10.35	0.72	0.44	p<0.001
			P	6.48 ± 0.05	7.85	0.51	ooo	
Head length (Hl)	cm	50	I	5.43 ± 0.04	7.74	0.42	0.22	p<0.001
			P	5.21 ± 0.03	5.77	0.30	ooo	
Caudal peduncle length (CPl)	cm	50	I	4.23 ± 0.05	12.03	0.51	0.26	p<0.001
			P	3.97 ± 0.04	9.80	0.39	ooo	

I – rainbow trout Irideus variety, P – rainbow trout Palomino variety.

Analyzing the average values of gravimetric and somatic measurements carried out, it reveals significant differences between the two varieties of rainbow trout, regarding body weight (Bw), total length (Tl), standard length (Sl), commercial length (Cl), small perimeter (p), head length (Hl) and caudal peduncle length (CPl). Significant differences were found for characters maximum height (H) and large perimeter (P) and insignificant differences for the minimum height (h) and body depth (Bd). Regardless of the meaning, all the differences were in favor of rainbow trout - Irideus variety.

As shown in table 4, the average weight of specimens of rainbow trout was 15.72 ± 0.33 g to the Irideus variety and 15.66 ± 0.33 g to the Palomino variety. Statistically insignificant difference between the mean initial body weight in two varieties (Ibw) (d = 0.06 g; $p>0.05$), shows that compliance with the conditions were installing this experiment. Finally, after 395 experimental days, the final body weight (Fbw) of both varieties was 284.77 ± 4.67 g for the Irideus variety, respectively 268.66 ± 3.38 g for the Palomino variety. Between the two varieties we found highly significant differences (d=16.11 g; $p<0.001$), in favor of Irideus variety. This indicates a higher growth dynamic for Irideus variety, compared to Palomino variety. In our vision, the differences are the result of the alimentary behavior of Palomino variety (Jobling et al 1995), which due to its intensive coloration, always exercised caution in the moments of feedings.

Table 4

Average values and significance of differences in dynamics and growth indices in the two varieties of rainbow trout (*Oncorhynchus mykiss*) Irideus vs. Palomino

Specification	*Group*	*Units*	*n*	*Variables*				
				$\overline{X} \pm s_{\overline{X}}$	*V%*	*s*	*d*	*semnif*
Initial body weight (Ibw)	I	g	50	15.72 ± 0.33	17.35	4.07	0.06 ns	p>0.05
	P	g	50	15.66 ± 0.28	17.50	3.98		
Final body weight (Fbw)	I	g	50	284.77 ± 4.67	16.42	46.74	16.11 ooo	p<0.001
	P	g	50	268.66 ± 3.38	12.58	33.81		
Total gain (TG)	I	g	50	269. 05 ± 1.28	14.71	7.73	16.05 ooo	p<0.001
	P	g	50	253.00 ± 2.45	18.36	6.22		
Average daily gain (ADG)	I	g/day	50	0.681 ± 0.01	13.75	0.06	0.041 o	p<0.05
	P	g/day	50	0.640 ± 0.01	14.78	0.11		

I – rainbow trout Irideus variety, P – rainbow trout Palomino variety.

Growth dynamics was assessed by two indices of growth: total gain (TG) and average daily gain (ADG).

At the end of the experimental period, Irideus variety shows a total gain (TG) of 269.05 ± 1.28 g and Palomino variety shows a total gain (TG) of 253.00 ± 2.45 g. The difference in growth recorded for this indices was highly significant (d = 16.05 g; $p<0.001$) in favor of Irideus variety.

In terms of average daily gain (ADG) it showed for the Irideus variety an average value of 0.681 ± 0.01 g and 0.640 ± 0.01 g for Palomino variety. Differences recorded between the mean values of average daily gain (ADG) in the two varieties was statistically significant (d = 0.041 g; $p<0.05$).

Analyzing average values and statistical significance of the differences between the two varieties of rainbow trout, regarding body size indices (Table 5), it is noted that in most cases the differences are insignificant.

A statistically significant difference in favor of Irideus variety (d = 0.44; $p<0.05$) was recorded for Meat indices 2 (Mi 2), where as the values of this indices are smaller, fish developed a higher meat quantity. Also, a very significant difference, but this time in favor of Palomino variety, was recorded for Fulton condition factor (K) (d = 0.06; $p<0.001$), where as the mean values to this indices are higher, shows a better state of maintenance. This is the result of the final weight of the two varieties, knowing that with

proper marketing excess body weight (200-250 g), body size indices have uncompliant values.

Table 5

Average values and statistical significance of the differences between the two varieties of rainbow trout (*Oncorhynchus mykiss*) - Irideus vs. Palomino, regarding calculated body size indices

Body size indices	*Group*	*n*	*Variables*				
			$\overline{X} \pm s_{\overline{X}}$	*V%*	*s*	*d*	*semnif*
Fulton condition factor (K)	I	50	1.23 ± 0.011	8.81	0.108	0.06	p<0.001
	P	50	1.29 ± 0.012	9.20	0.118	***	
Thickness indices (Ti)	I	50	16.25 ± 0.157	9.65	1.569	0.03	p>0.05
	P	50	16.22 ± 0.183	11.30	1.833	ns	
Profile indices (Pi)	I	50	3.62 ± 0.022	6.00	0.217	0.03	p>0.05
	P	50	3.59 ± 0.020	5.57	0.200	ns	
Quality indices (Qi)	I	50	1.29 ± 0.013	10.33	0.134	0.02	p>0.05
	P	50	1.31 ± 0.015	11.78	0.155	ns	
Meat indices 1 (Mi 1)	I	50	20.93 ± 0.129	6.16	1.289	0.17	p>0.05
	P	50	20.76 ± 0.095	4.55	0.945	ns	
Meat indices 2 (Mi 2)	I	50	16.27 ± 0.126	7.72	1.256	0.44	p<0.05
	P	50	15.83 ± 0.124	7.86	1.245	o	

I – rainbow trout Irideus variety, P – rainbow trout Palomino variety.

Conclusions. Biological material represented by two varieties of rainbow trout (*Oncorhynchus mykiss*) - Irideus, Palomino respectively, throughout the experiment received the same environmental conditions, the same feed and same manner and frequency of feeding. Values of physico-chemical parameters of water in Gilău trout farm were within normal limits, consistent with the biological requirements of rainbow trout throughout the experiment. At the end of the experiment, it was found highly significant differences between the two varieties of body weight, in favor of Irideus variety. Regarding the total gain (TG), for Irideus variety it was 269.05 ± 1.28 g and 253.00 ± 2.45 g for Palomino variety. Average daily gain (ADG) for Irideus variety was 0.681 ± 0.01 g and 0.640 ± 0.01 g for Palomino variety. Analyzing average values of body size indices used, the differences between the two varieties are statistically insignificant except Fulton condition factor (K), which presented positive values for Irideus variety. Our results reflect a lower growth dynamic for the Palomino variety compared to conventional variety Irideus, which calls into question the opportunity for exploitation of this variety of trout. Palomino variety, yet lends itself to be exploited as ornamental trout in ponds nearby tourist hostels, where due to intense coloration may be interesting for tourists and consumers.

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