

# The Polyculture of Sterlet (*Acipenser ruthenus*) and Carp (*Cyprinus carpio*) in Recirculating Aquaculture Systems. The Effects on Fish Growth Dynamic and Production

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## Abstract

The polyculture of two or more fish species is very common in ponds, this fish culture technique being relatively newly applied in recirculating aquaculture systems (RAS). The aim of this study is to evaluate the effects of polyculture of the sterlet (*Acipenser ruthenus*) and common carp (*Cyprinus carpio*) (30-60%) into recirculating aquaculture system on growth dynamic of the fish and tank's bio-productivity. Two variants of polyculture have been tested during a month in duplicate: V1 - sterlet with 30% carp (200 sterlets and 60 carps/ 1 m<sup>3</sup> tank); V2 - sterlet with 60% carp, (200 sterlets and 120 carps/1 m<sup>3</sup> tank). The control group (C) contains sterlet in monoculture (200 sterlets/ 1 m<sup>3</sup> tank). The polyculture for 28 days of the sterlets with carps 30% (V1) or 60% (V2) did not significantly ( $p>0.05$ ) influence the sterlets' growth dynamic. Bio-productive parameters were better in the polyculture variant where sterlets were farmed with 30% carps. Polyculture could be a good way to positively influence the fingerling sterlet farming in RAS, having a beneficial impact on tank's bio-productivity. A significant plus of fish biomass (carp) resulted by valorisation of the pellets unconsumed by the sterlet, was obtained in both polyculture variants.

**Keywords:** carp, polyculture, RAS, sterlet.

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## 1. Introduction

The polyculture of two or more fish species into the same pond is very common in aquaculture farms where extensive and semi-intensive farming systems are practiced. This fish culture technique is widely found in ponds [1] due to its advantage in a better utilization of different trophic and spatial niches [2]. Actually, the polycultures of the fish with other fish or animal species or even plants, have proved to have beneficial impact on production in aquaculture farms [3, 1, 4-7] the natural food resources being much more efficiently used by the multispecies populations [1]. Even the polyculture is very common in

ponds, this fish culture technique is relatively newly applied in recirculating aquaculture systems (RAS) where intensive or highly-intensive rearing systems are practiced. RAS is based on the water recycling using mechanical and biological filters being designed for many fish species especially for fish with highly economical value [8, 9]. The monoculture applied in some species in RAS, has proved to have some issues very easily passed by means of polyculture. If the fishes eat pellets exclusively in the water column (for example pikeperch) [10], a polyculture of this species with a bottom feeder fish could bring many advantages [1, 11-14]. The information of the sturgeon polyculture with other fish species in RAS are sparse and studies regarding the possibility of production increasing by means of this culture techniques or based on other technological solutions with minimum investment are needed.

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The aim of this study is to evaluate the effects of polyculture of the sterlet (*Acipenser ruthenus*) and common carp (*Cyprinus carpio*) (30-60%) into recirculating aquaculture system on growth dynamic of the fish and tank's bio-productivity.

## 2. Materials and methods

Five-months-old sterlet and 3-month-old common carp have been used for our trials. Both species have been obtained by means of artificial reproduction, in the recirculating aquaculture system (RAS) from the Banat's University of Agricultural Science and Veterinary Medicine "King Michael I of Romania" from Timisoara in March and May 2020, respectively. Until the beginning of the experiment both species have been reared in monocultures and the same type of dry food was used for their feeding.

The study has been carried on in two identical recirculating aquaculture systems with 3 rectangular fiberglass tanks each, and 1 cubic meter per tank.

Two variants of polyculture have been tested during a month in duplicate: V1 - sterlet with 30% carp (200 sterlets and 60 carps/tank); V2 - sterlet with 60% carp, (200 sterlets and 120 carps/tank). The control group (C) contains sterlet in monoculture (200 sterlets/tank).

At the beginning of the experiment, the sterlet had an average body weight of  $67.93 \pm 1.63$  g in V1,  $69.8 \pm 1.91$  g in V2 and  $69.3 \pm 2.45$  g in C. The carp, used as a supplementary species in the polyculture variants, had an average body weight between 12.35 g and 13.00 g/individual.

The main physical and chemical water parameters were measured with the spectrophotometer DR3900 (Hach Lange, Germany) (ammonium, nitrites and nitrates) and with the multiparameter Hanna (Hanna Instruments, Romania) (temperature and dissolved oxygen). The values of these parameters were: temperature  $23.5 \pm 1^\circ\text{C}$ , dissolved oxygen 4.3-6.4 mg/l, nitrates <150 mg/l, ammonium <0.3 mg/l, nitrites <0.9 mg/l. One and a half cubic meter of water from each RAS was daily replaced with fresh water from the well heated at RAS' temperature with solar panels.

The fish were fed with dry feed STAR ALEVIN (Alltech-Coppens, The Netherlands) the size of the pellets being 2 mm. The food quantity was calculated as 3% of the total biomass of sterlet in

the control group and the initial calculated quantity (420 g/tank) was used for fish feeding in all variants during all experimental period. Feeding was done 24/24 h, using semi-automatic FIAP belt feeders (FIAP, Germany).

Thirteen fish randomly caught from each species and variant were weekly measured for the evaluation of the growth dynamics [15, 16]. The total length (TL) and the body weight (BW) for both species were measured after the fish were anesthetized with clove oil (0.05 ml/500ml water) to avoid stress and all reactions during manipulations [17].

The mean, standard deviation (SD), standard error (SE) and coefficient of variation (CV) have been calculated for each morphometric trait of both fish species.

The Specific Growth Rate (SGR) the Body Weight ( $\text{SGR}_{\text{BW}}$ ) and Total Length ( $\text{SGR}_{\text{TL}}$ ), the Daily Growth Rate (DGR) and Feed Conversion Rate (FCR) were calculated using the following formulas:

Specific growth rate (% day<sup>-1</sup>);

$\text{SGR}_{\text{BW}} = [(\ln \text{ final BW} - \ln \text{ initial BW}) / \Delta T] \times 100$

$\text{SGR}_{\text{TL}} = [(\ln \text{ final TL} - \ln \text{ initial TL}) / \Delta T] \times 100$

Daily growth rate (g d<sup>-1</sup>);

$\text{DGR} = (\text{final BW} - \text{initial BW}) / \Delta T$

Feed conversion rate;

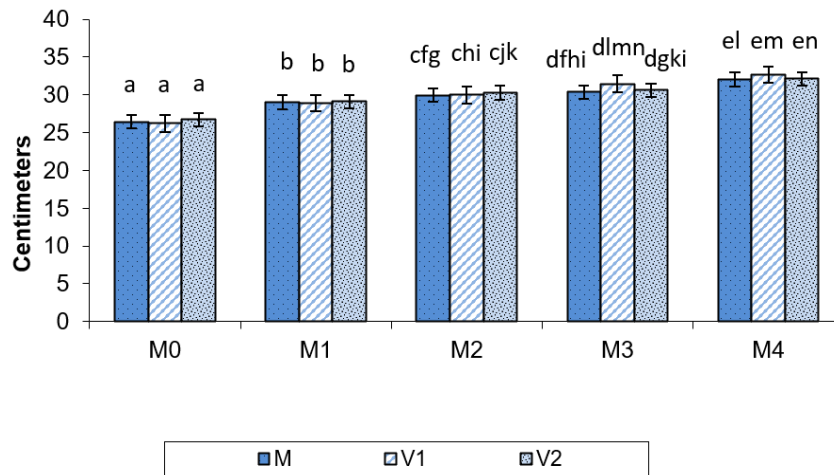
$\text{FCR} = \text{Feed distributed} / (\text{final Biomass} - \text{initial Biomass})$ ;

where:  $\Delta T$  is the duration of the experiment, the other being described above.

The data was analysed using STATISTICA10 software. Kruskal-Wallis test was used to assess the significance of differences. The data statistically processed are presented into the paper as Mean $\pm$ SD.

## 3. Results and discussion

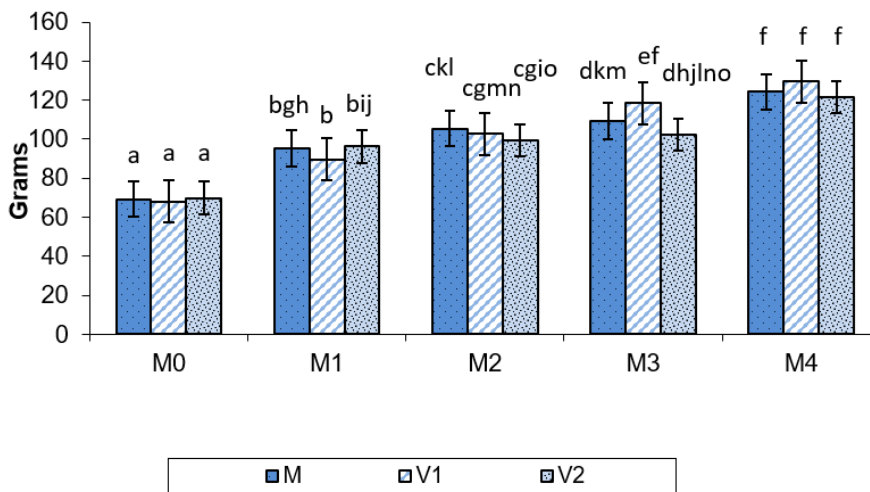
The TL and the BW of the sterlet fingerlings significantly increased ( $p \leq 0.001$ ) during 28 days in all trials, and the differences among the variants were very low. Therefore, even if the sterlet from V1 reached at the end of the experimental period a TL of  $32.67 \pm 1.65$  cm, with 0.54 cm higher than the fish from V2 and 0.60 cm higher than the sterlet from the control group (C) (table 1), these differences were not significant ( $p > 0.05$ ) (figure 1).



**Figure 1.** The weekly dynamic of the total length and the significance of the differences in sterlet. M0-M4-weekly measurements. Same letter indicates not significant differences ( $p>0.05$ )

The sterlet from V1 reached  $129.43 \pm 19.88$  g at the end of the experimental period, the fish from this variant being with 7,81 g heavier than the fish from V2 and with 5,27g heavier than the sterlet

from the control group (C) (table 2). Anyway, these differences were not significant ( $p>0.05$ ) (figure 2).



**Figure 2.** The weekly dynamic of the body weight and the significance of the differences in sterlet. M0-M4-weekly measurements. Same letter indicates not significant differences ( $p>0.05$ )

**Table 1.** Dynamics of the total length - TL (cm) of the sterlet during the 28 days (n=30)

Specification	M0			M1			M2			M3			M4		
	C	V1	V2	C	V1	V2	C	V1	V2	C	V1	V2	C	V1	V2
Mean (cm)	26.45	26.22	26.72	29.07	28.90	29.10	30.31	29.97	30.01	30.35	31.47	30.61	32.07	32.67	32.13
SD	1.75	1.32	1.53	1.42	1.38	1.28	1.50	1.56	1.39	1.97	1.87	1.72	1.69	1.83	1.65
SE	0.32	0.24	0.28	0.25	0.25	0.23	0.27	0.28	0.25	0.36	0.34	0.31	0.30	0.33	0.30
CV	6.64	5.05	5.76	4.89	4.78	4.41	4.96	5.20	4.65	6.51	5.96	5.62	5.28	5.60	5.15

M0-M4-the weekly measurements; SD-standard deviation; SE- standard error; CV-coefficient of variation; C-control; V1 and V2-trials

**Table 2.** Dynamics of the body weight - BW (g) of the sterlet during the 28 days (n=30)

Specification	M0			M1			M2			M3			M4		
	C	V1	V2	C	V1	V2	C	V1	V2	C	V1	V2	C	V1	V2
Mean (cm)	69.3	67.93	69.8	95.2	89.66	96.16	105.3	102.7	99.3	109.23	118.5	102.13	124.16	129.43	121.62
SD	13.46	8.932	10.47	11.57	11.90	22.78	16.73	16.06	13.34	18.71	21.44	18.35	22.34	19.88	20.18
SE	2.45	1.63	1.91	2.11	2.17	4.16	3.05	2.93	2.43	3.41	3.91	3.35	4.07	3.62	3.68
CV	19.42	13.15	15.01	12.15	13.27	23.69	15.89	15.64	13.43	17.12	18.09	17.96	17.99	15.35	16.59

M0-M4-the weekly measurements; SD-standard deviation; SE- standard error; CV-coefficient of variation; C-control; V1 and V2-trials

The carp reared as supplementary species with sterlet in V1 (30%) had a better growth than in V2 (60%) (tables 3, 4 and figures 3, 4). Therefore, the carps in the trial V1 had a very good growth in

TL, reaching 14.64±1.13 cm as against the variant V2 where the fish were smaller with 0.72 cm, the difference being a significant one (p<0.001).

**Table 3.** Dynamics of the total length - TL (cm) of the carp during the 28 days (n=30)

Specification	M0		M1		M2		M3		M4	
	V1	V2	V1	V2	V1	V2	V1	V2	V1	V2
Mean (cm)	8.81	8.82	10.20	10.40	11.6	11.48	13.35	12.9	14.64	13.92
SD	0.47	0.34	0.84	0.53	0.79	0.82	0.87	0.87	1.13	1.07
SE	0.08	0.06	0.15	0.09	0.14	0.15	0.16	0.16	0.2	0.19
CV	5.37	3.95	8.32	5.10	6.88	7.22	6.57	6.81	7.77	7.70

M0-M4-the weekly measurements; SD-standard deviation; SE-standard error; CV-coefficient of variation; V1 and V2-

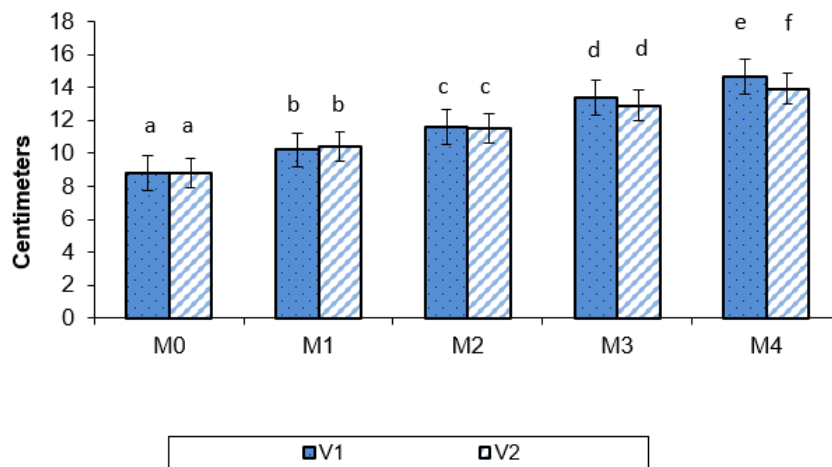
**Table 4.** Dynamics of the body weight - BW (g) of the carp during the 28 days (n=30)

Specification	M0		M1		M2		M3		M4	
	V1	V2	V1	V2	V1	V2	V1	V2	V1	V2
Mean (g)	13.00	12.35	23.33	24.68	36.81	34.81	56.16	47.75	77.03	62.97
SD	2.47	1.51	4.58	4.11	8.12	8.07	12.07	9.01	14.67	15.20
SE	0.45	0.27	0.83	0.75	1.48	1.47	2.20	1.64	2.67	2.77
CV	19.01	12.26	19.64	16.65	22.07	23.20	21.49	18.88	19.05	24.14

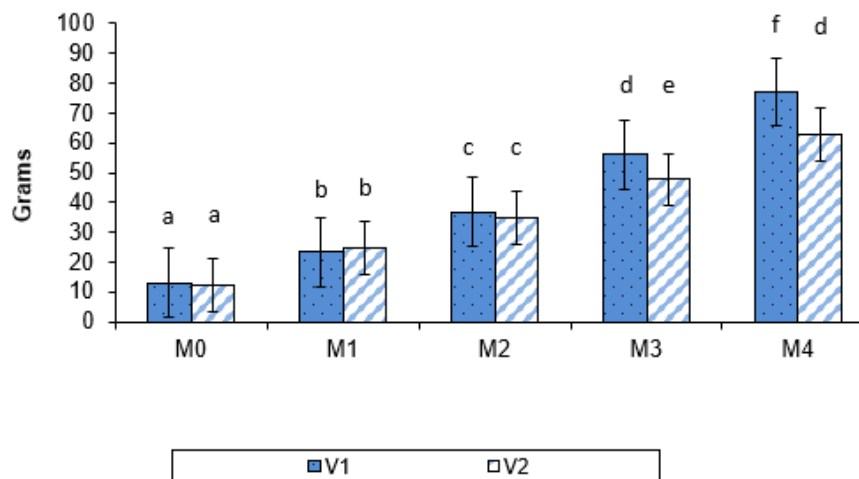
M0-M-the weekly measurements; SD-standard deviation; SE-standard error; CV-coefficient of variation; V1 and V2-trials

The body weight growth was very significant (p<0.001) in the carps from V1 their BW raising with 492.53% in 28 days, from 13.00±2.47 g to 77.03±14.67 g. This was a significant (p<0.05)

better growth than in V2 where the carps reached 62.97±15.20 g, being with 409.88% heavier than at the start of the experimental period.



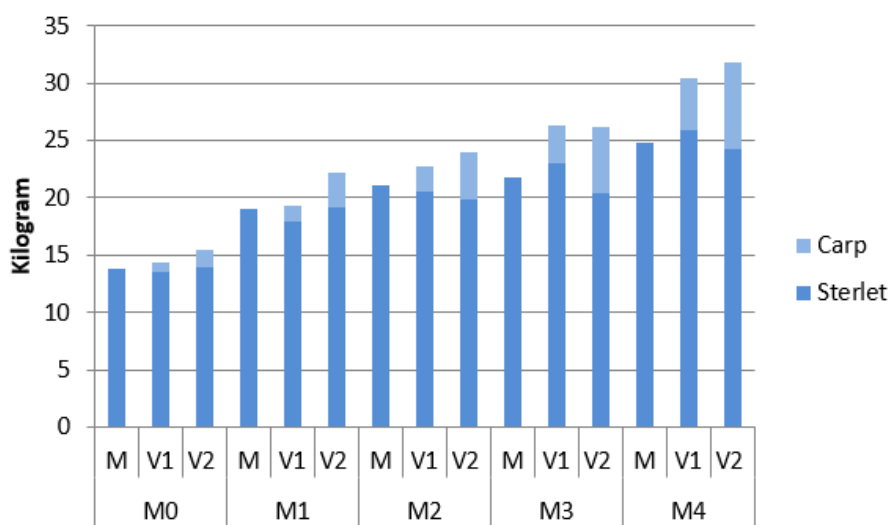
**Figure 3.** The weekly dynamic of the total length and the significance of the differences in carp. M0-M4-weekly measurements. Same letter indicates not significant differences (p>0.05)



**Figure 4.** The weekly dynamic of the body weight and the significance of the differences in carp. M0-M4-weekly measurements. Same letter indicates not significant differences ( $p>0.05$ )

The total biomass per m<sup>3</sup> at the end of the experimental period was higher in the trial V2 (31.87 kg) as against of V1 (30.50 kg) (figure 5).

The higher biomass in V2 could be due to a higher number of fish in this variant. Anyway, the body weight mean of the carps from V2 was significantly lower than in V1.



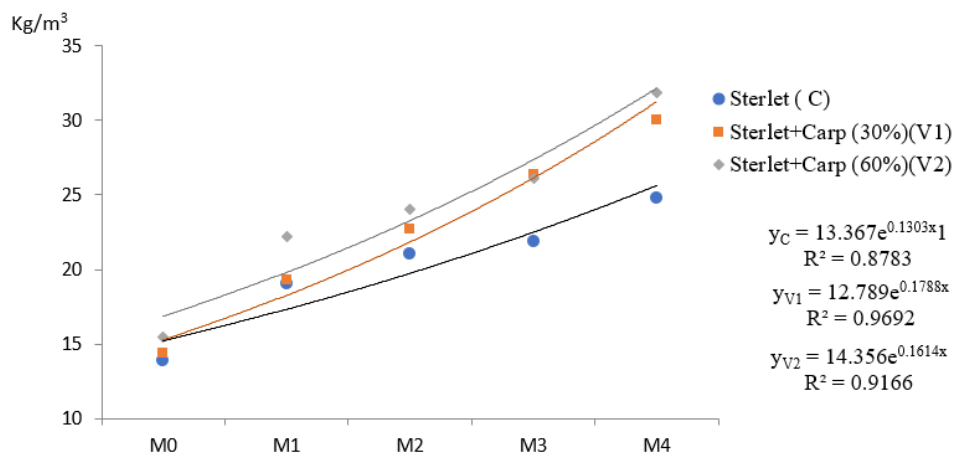
**Figure 5.** Graphical representation of fish biomass growth (kg/m<sup>3</sup>) during experimental period

The Specific Growth Rate (SGR) the Body Weight (SGR<sub>BW</sub>) and Total Length (SGR<sub>TL</sub>), and the Daily Growth Rate (DGR) are superior in the

polyculture variant V1, the data being highlighted in the table 5.

**Table 5.** Bio-productive parameters of the sterlet at the end of experimental period (28 days) in the experimental variants

Specification	Control	V1	V2
SGR <sub>BW</sub> (% day <sup>-1</sup> )	2.08	2.32	1.98
SGR <sub>TL</sub> (% day <sup>-1</sup> )	0.68	0.78	0.65
DGR (g)	1.95	2.19	1.85
FCR (sterlet)	1.11	0.99	1.18
FCR (sterlet+carp)	-	0.75	0.74



**Figure 6.** Fish biomass dynamic during 28 days, mathematically adjusted, in control and experimental variants

The Feed Conversion Rate (FCR) was very good for the trial V1 when it was calculated for the sterlet (0.99) and for the total biomass (sterlet and carp: 0.75). FCR for the trial V2 proved to be at the same level like V1 when it was calculated for total biomass (0.74) but higher if it was calculated for the sterlet (1.18). Therefore, the polyculture of the sterlet with carp could lead to a better valorisation of the food, FCR being relevant in this respect.

#### 4. Conclusions

The polyculture for 28 days of the sterlets with carps 30% (V1) or 60% (V2) did not significantly ( $p > 0.05$ ) influence the sterlets' growth dynamic.

Bio-productive parameters were better in the polyculture variant where sterlets were farmed with 30% carps (V1).

Polyculture could be a good way to positively influence the fingerling sterlet farming in RAS, having a beneficial impact on tank's bio-productivity.

A significant plus of fish biomass (carp) resulted by valorisation of the pellets unconsumed by the sterlet, was obtained in both polyculture variants (V1, V2).

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