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Polyculture in three sowing densities of Colossoma macropomum "gamitana" and Oreochromis spp. (O. niloticus var. Stirling x O. aureus) "hybrid tilapia" in an intensive system

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Abstract: *This research was developed with the objective of determining the effect of the density of sowing on the growth of Colossoma macropomum and Oreochromis spp. (O. niloticus var. Stirling x O. aureus) in intensive polyculture, for each applied Increased Stimulus Experimental Design with three treatments without repetition: 5.5 fish/m^2 (pond 1), 6.0 fish/m^2 (pond 2) and 6.5 fish/m^2 (pond 3), becoming vary the density of C. macropomum: 1.5, 2.0 and 2.5 fish/m^2, respectively and keeping the density of second in 4 fish/m^2. The monthly biometric control of growth became taking homogeneous samples of 25 specimens of C. macropomum and 50 of Oreochromis spp.; using analysis of variance, Tukey test and analysis of covariance, to determine significant differences in growth in length and weight. Records of temperature and pH were also made. The growth of C. macropomum and Oreochromis spp. it was positively affected by planting density being higher to density of 6.5 fish/m^2: 157.16 mm and 70.31 g for the first and 231.30 mm and 285.20 g for the second; effect that was also corroborated by the analysis of covariance which showed significant differences between the parameters of the weight - length relationship. The highest total and gross production were reached in 6.5 fish/m^2 density: 155.14 kg and 12 120.70 kg / ha. Feed conversion factors were low: 0.95 (5.5 fish/m^2), 1.23 (6 fish/m^2) and 1.11 (6.5 fish/m^2). The temperature and pH of the water of the ponds were very similar, although the first declined to levels which affected the growth of C. macropomum.*

Keywords*: Intensive Polyculture, C. macropomum and Oreochromis spp., plant densities.*

Introduction

In extensive and semi-intensive farming systems, a highly recommended technique to increase the total productive yield of the pond is the polyculture of two or more species that allow optimal use of natural production at different levels of the water column; which implies an adequate choice of species to take advantage of those spaces and ecological niches of the aquatic environment; however, in the intensive system, where the growth of the fish depends exclusively on the balanced food, the use of this technique seeks to take advantage of the available spaces as well as the reuse of the waste of the organisms that are located in the upper levels by the those who are located in the lower levels; being necessary for this, a wide knowledge of their bioecology, especially, their eating habits and their distribution depending on the depth.

Considering these premises, in the present study the use of the species *Oreochromis spp*. (*O. niloticus var. Stirling* x *O. aureus*) "hybrid tilapia", a pelagic fish that occupies the upper level of the water column and has an omnivorous and filter-feeding regime, together with *Colossoma macropomum* "gamitana", an Amazonian species that is located in intermediate and lower levels of the column, being its omnivorous regime that takes advantage of the food available in the aquatic environment.

In the department of Lambayeque, polycultures of *O. niloticus* and tilapia hybrids have been carried out with native species of the area such as *Mugil cephalus*, *Trichomycterus punctulatus*, *Lebiasina bimaculata*, *Aequidens rivulatus* and *Dormitaotr latifrons*, in semi-intensive systems, feeding them with powdered rice and balanced feed for poultry as well as fish and in systems associated with raising ducks; a similar experience has also been carried out by López et al. (2011), of a polyculture of (*O. niloticus var. Stirling* x *O. aureus*), pacotana (*C. macropomum x Piaractus brachipomus*) and pocoche (*D. latifrons)* using balanced food and with different population densities of tilapia (1, 1.5 and 2 fish/m2), with very good results; considering the need to continue with the polyculture experiences, fixing the density of tilapia and varying the density of gamitana, but in an intensive culture system with these two species, also considering that the Batangrande area is a warm environment conducive to culture of these two fishery resources.

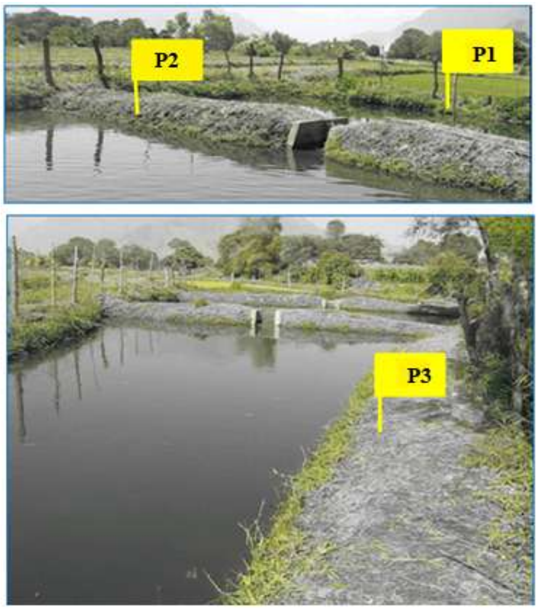
Under these conditions, the present investigation entitled Polyculture in three planting densities of *C. macropomum* and *Oreochromis spp*. (*O. niloticus Var. Stirling x O. aureus*) hybrid tilapia in an intensive system, in which the growth in length and weight of these two species at different densities has been determined and compared; formulating the problem How does the planting density affect the growth of *C. macropomum* and Oreochromis spp? in the modality of polyculture and intensive culture system?, to which the hypothesis was raised: If the stocking density of the culture pond affects the growth of the fish in an inverse relationship, then the growth of *C. macropomum* and *Oreochromis spp*. it will be better in the lower density; hypothesis that was contrasted with the Increasing Stimulus Experimental Design.

Material y Methods

The polyculture was carried out from March to July 2014, in the "Tilapia" Fish Farm owned by Mr. Segundo Saldaña, located in the Manchuria B farmhouse of the San Luis Population Center, district of Pítipo, province of Ferreñafe and department of Lambayeque, at the coordinates 6º27'12" S and 79º 38' 11" W, at an altitude of 117 meters above sea level, distant 52.10 km from the city of Chiclayo; having 3 semi-natural ponds of: 105 m2 (Pond 1), 140 m2 (Pond 2) and 128 m2 (Pond 3), which were supplied with water from the La Leche River. (Figure 1).

Figure 1

Arrangement of polyculture ponds for C. macropomum and Oreochromis spp.



The *C. macropomum* fingerlings were obtained from the Tarapoto Fish Farm and the "hybrid tilapia" fingerlings were purchased from a Private Laboratory in the city of Moyobamba-San Martín.

The stocking of the fish in the culture ponds was done in a staggered manner, first the "hybrid tilapia" was stocked and one month later the "gamitana" fingerlings. (Figure 2).

The hypothesis was contrasted with the Growing Stimulus Experimental Design with three treatments, without repetition: 5.5 fish/m2 (Pond 1), 6 fish/m2 (Pond 2) and 6.5 fish/m2 (Pond 3). The stocking density of Oreochromis spp was 4 fish/m2 in all the ponds, while that of C. macropomum varied: 1.5 fish/m2 (Pond 1), 2 fish/m2 (Pond 2) and 2.5 fish/m2 (Table 1).

Figure 2
Stocking of C. macropomum fingerlings

Table 1
Experimental design, denomination of the ponds, average lengths and weights and total population of C. maropomum and Oreochromis spp., in the intensive polyculture modality, march - july 2014.

Ponds	*C. macropomum*			*Oreochromis spp*			Overall density	Total population
	Density	Lt (mm)	Wt (g)	Density	Lt (mm)	Wt (g)		
P1	1,5	28,80	0,46	4,0	24,30	0,23	5,5	578
P2	2,0	28,80	0,46	4,0	24,30	0,23	6,0	840
P3	2,5	28,80	0,46	4,0	24,30	0,23	6,5	832

The fish population of the ponds was: 420 tilapias and 158 gamitanas for Pond 1 (578 fish), 560 tilapias and 280 gamitanas for Pond 2 (840 fish) and 512 tilapias and 320 gamitanas for Pond 3 (832 fish).

The feeding of the fish was carried out with balanced food of 45% protein at a rate of 20% of the biomass for tilapia for 15 days, after 40% protein with an index of 8% of the biomass until the first month. falling to 4% the second month; the third and fourth month of cultivation, it was fed a diet of 32 % protein at a rate of 3 and 2.5 % of the biomass, to finally feed it in the fifth month with a diet of 28 % protein with an index of 1 % of the biomass. In the case of the gamitana, it was fed with the same diet as for tilapia from the second month, that is, it started with 40 % protein the first month, 32 % protein the second and third, and 28 % protein the fourth; being the feeding indices of 8%, 5%, 4%, and 3% of the biomass, respectively. The delivery of the food was made in double hours: 09:00 and 14:00 h.

The growth in length and weight was recorded monthly, for which a 10 m long by 1.5 m high anchovy cloth hammock was used, taking homogeneous samples for each species: 25 gamitanas and 50 tilapia, which were placed in plastic buckets with water. The total length in millimeters was taken with an Ichthyometer and the total weight in grams with a digital balance. (Figure 3).

The surface water and ambient temperatures were recorded daily at 08:00 and 13:00 h, with a digital thermometer in °C. The pH of the pond water was controlled weekly with the help of a Hanna Potentiometer.

At the end of the culture process, to determine the effect of planting density, time and their interaction on fish growth, the analysis of variance was applied for a factorial design (Ostle, 1994), with the model being:

$$Y_{ijk} = U + Ai + Bj + (AB)_{ij} + Eijk$$

Where:
Y_{ijk} : Any measurement
U : True average length or weight
A_i : Effect of the planting density factor on growth
B_j : Effect of the time factor on growth
$(AB)_{ij}$: Effect of the interaction of the two factors on growth
E_{ijk} : Experimental bug.

Figure 3
Biometric control of C. maropomum and Oreochromis spp.

The following hypotheses were raised:

Ho: The sowing density factor, time and the interaction of both factors do not affect the growth of *C. macropomum* and *Oreochromis spp.*

Ha: The sowing density factor, time and the interaction of both factors do affect the growth of *C. macropomum* and *Oreochromis spp.*

Decisions were made based on the following:

Accept Ho if P is greater than 0.05
Accept Ha if P is less than 0.05

Using Tukey's multiple range test, it was evidenced in favor of which treatment the significant differences in growth were presented.

The weight-length equations were estimated for each treatment and were compared by analysis of covariance (Zar, 1996). On the other hand, the t test was applied for the exponent b (Snedecor and Cochram, 1967), in order to establish if it differs statistically from three and thus typify growth.

The statistical analyzes were processed with a Laptop Hp CORE I3 system, using the statistical program Minitab 16 and Excel 2007, with a significance level of 0.05.

Results

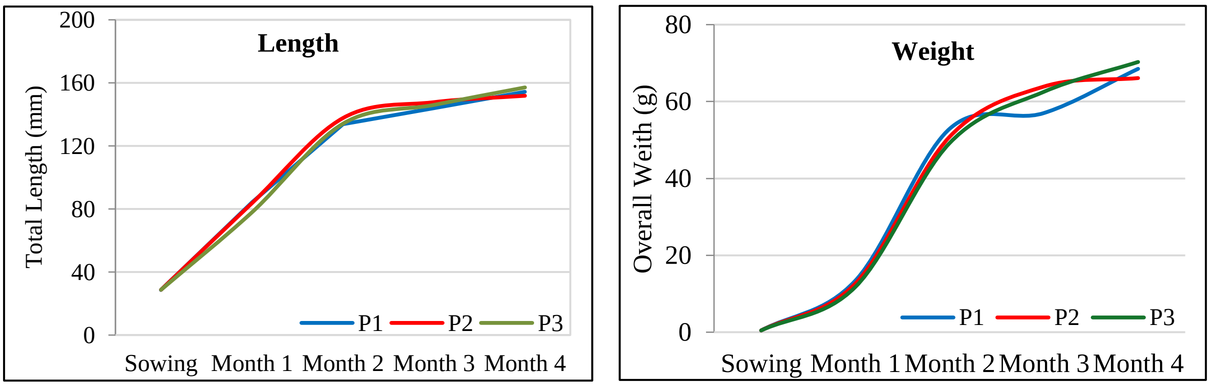
3.1 Growth of *C. macropomum*

The growth of *C. macropomum* presented slight differences from one treatment to another, observing that the greatest final average length and weight was achieved at a density of 2.5 fish/m2: 157.16 mm and 70.31 g (Pond 3) (Table 2). The graphic analysis (Figure 4), indicated that the growth of the fish, in length and weight, was more or less similar until the third month of culture, from which a better performance of the gamitanas was observed cultured at a density of 2.5 fish/m2.

Table 2
Mean lengths and weights of sowing and monthly of C. macropomum, in polyculture at three planting densities with Oreochromis spp. in an intensive system, march – july 2014.

Time	Pond 1			Pond 2			Pond 3		
	n	Lt (mm)	Wt (g)	n	Lt (mm)	Wt (g)	n	Lt (mm)	Wt (g)
Sowing	158	28,80	0,46	280	28,80	0,46	320	28,80	0,46
Month 1	25	84,40	13,42	25	83,76	12,68	25	77,96	11,78
Month 2	25	133,88	52,92	25	137,76	50,85	25	134,16	49,20
Month 3	25	143,92	57,02	25	147,80	63,91	25	146,08	62,55
Month 4	25	154,44	68,52	25	151,88	66,12	25	157,16	70,31

Figure 4
Variations of monthly mean lengths (A) and weights (B) of C. macropomum, in polyculture at three planting densities with Oreochromis spp. in an intensive system, march – july 2014.



Through the analysis of variance (Table 3), it was shown that the growth of the fish did not present significant differences (p>0.05) between treatments, but it did differ according to time, consequently, the growth of C. macropomum was not affected by the planting density, but by the time factor; on the other hand, it was not affected by the interaction of the two factors either.

Table 3
Analysis of variance to determine the effect of planting density, time and their interaction on the growth, in length and weight, of C. macropomum, in polyculture at three planting densities with Oreochromis spp. in an intensive system, march – july 2014.

Source of variation	Length		Weight	
	F	p	F	p
Treatments	0,19	0,82	0,01	0,99
Time	202,13	0,00	91,52	0,00
Interaction	0,75	0,61	0,36	0,91

F: Test value of F; p < 0,05

Tukey's test as a function of time (Table 4), showed that growth is significant only in the second month of culture, in the three treatments, both for weight and length.

The study of the monthly increase rates indicated that in length, they observed a tendency to decrease their value with the passage of cultivation time, while in weight, they increased towards the second month of cultivation and then began to decrease in the last two months (Table 5).

Table 4

Tukey's test to determine significant differences month by month between the mean lengths and weights of C. macropomum, in polyculture at three planting densities with Oreochromis spp. in an intensive system, March – July 2014.

Length					Weight				
Time	Pond 1		Diference	DMS	Time	Pond 1		Diference	DMS
Month 1-Month 2	84,40	133,88	49,48*	16,97	Month 1-Month 2	13,42	52,92	39,50*	23,50
Month 2-Month 3	133,88	143,92	10,04	20,28	Month 2-Month 3	52,92	57,02	4,09	19,67
Month 3-Month 4	143,92	154,44	10,52	24,69	Month 3-Month 4	57,02	68,52	11,50	25,77
	Pond 2					Pond 2			
Month 1-Month 2	83,76	137,76	54,00*	20,28	Month 1-Month 2	12,68	50,85	38,16*	23,50
Month 2-Month 3	137,76	147,80	10,04	22,24	Month 2-Month 3	50,85	63,91	13,06	25,77
Month 3-Month 4	147,80	151,88	4,08	16,97	Month 3-Month 4	63,91	66,12	2,21	19,67
	Pond 3					Pond 3			
Month 1-Month 2	77,96	134,16	56,20*	22,24	Month 1-Month 2	11,78	49,20	37,42*	23,50
Month 2-Month 3	134,16	146,08	11,92	20,28	Month 2-Month 3	49,20	62,55	13,35	25,77
Month 3-Month 4	146,08	157,16	11,08	23,65	Month 3-Month 4	62,55	70,31	7,76	27,41

*: Significant value at 0.05; DMS: Tukey's Least Significant Difference.

Table 5

Monthly increases in mean lengths and weights of C. macropomum, in polyculture at three planting densities with Oreochromis spp. in an intensive system, march – july 2014.

Time	Pond 1			Pond 2			Pond 3		
	n	Lt (mm)	Wt (g)	n	Lt (mm)	Wt (g)	n	Lt (mm)	Wt (g)
S-M1	158	55,60	12,96	280	54,96	12,22	320	49,16	11,32
M1-M2	25	49,48	39,50	25	54,00	38,17	25	56,20	37,42
M2-M3	25	10,04	4,10	25	10,04	13,06	25	11,92	13,35
M3-M4	25	10,52	11,50	25	4,08	2,21	25	11,08	7,76

S: sowing; M: Month

3.2 Growth of *Oreochromis spp*

The growth of hybrid tilapia differed from one treatment to another, being higher in the total density of 6.5 fish/m2 (Pond 3): 231.30 mm and 285.20 g (Table 6). Graphically (Figure 5), it was possible to show that the greatest growth of the fish in favor of the density indicated above, occurred from the first month of culture.

The analysis of variance (Table 7) determined that the differences observed, between the mean lengths and weights, are statistically significant and therefore the growth of the fish was affected by the stocking density, in addition to the time and the interaction between both factors.

The Tukey test (Table 8), allowed establishing, in a general way, that the differential growth in favor of the total density of 6.5 fish/m2 (Pond 3), occurred in the last two months of the polyculture; likewise, that between the total densities of 5.5 and 6.0 fish/m2, no significant differences in growth were observed.

The analysis of growth as a function of time through the Tukey test (Table 9), showed that growth was significant during the entire culture period in the three treatments, both in length and in weight.

The evaluation of the monthly increase rates (Table 10), established that, in length, their values presented a tendency to decrease from the beginning to the end of the crop; instead, in weight, these increased from the beginning to the fourth month of cultivation and then decreased in the fifth. The best rates of increase occurred in the total density of 6.5 fish/m2 (Pond 3).

Table 6
Mean lengths and weights of sowing and monthly of Oreochromis spp., in polyculture in three sowing densities with C. macropomum in an intensive system, March – July 2014.

Time	Pond 1			Pond 2			Pond 3		
	n	Lt (mm)	Wt (g)	n	Lt (mm)	Wt (g)	n	Lt (mm)	Wt (g)
Sowing	470	24,30	0,23	560	24,30	0,23	512	24,30	0,23
Month 1	50	87,52	11,74	50	89,52	14,96	50	93,06	16,66
Month 2	50	127,98	48,25	50	137,96	59,09	50	141,54	63,86
Month 3	50	167,40	113,75	50	170,10	117,96	50	173,52	122,07
Month 4	50	201,60	189,69	50	207,44	208,45	50	217,22	213,78
Month 5	50	228,52	248,28	50	217,38	238,01	50	231,30	285,20

Figure 5
Variations of monthly mean lengths and weights of Oreochromis spp., in polyculture at three planting densities with C. macropomum in an intensive system, March – July 2014.

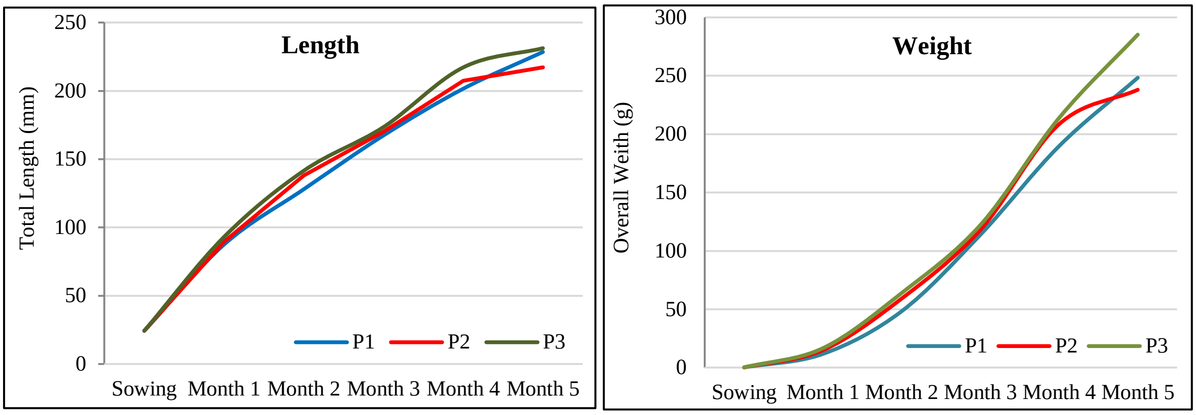


Table 7
Analysis of variance to determine the effect of planting density, time and their interaction on the growth, in length and weight, of Oreochromis spp., in polyculture at three planting densities with C. macropomum in an intensive system, march - july 2014.

Source of variation	Length		Weigth	
	F	p	F	p
Treatments	20,22	0,00	12,17	0,00
Time	1740,18	0,00	867,60	0,00
Interaction	3730,00	0,00	3,13	0,00

F: Valor de prueba de F; p < 0,05

Table 8

Tukey test to determine significant differences between treatments for mean monthly lengths and weights of Oreochromis spp., in polyculture at three planting densities with C. macropomum in an intensive system, march – july 2014.

Length					Weight				
Time	P1	P2	Diference	DMS	Time	P1	P2	Diference	DMS
Month 1	87,52	89,52	2,00	6,32	Month 1	11,74	14,96	3,21	16,38
Month 2	127,98	137,96	9,98*	6,32	Month 2	48,25	59,09	10,84	16,38
Month 3	167,40	170,10	2,70	6,32	Month 3	113,75	117,96	4,22	16,38
Month 4	201,60	207,44	5,84	6,32	Month 4	189,69	208,45	18,76*	16,38
Month 5	228,52	217,38	11,14*	6,32	Month 5	248,28	238,01	10,27	16,38
	P1	P3				P1	P3		
Month 1	87,52	93,06	5,54	7,56	Month 1	11,74	16,66	4,91	19,57
Month 2	127,98	141,54	13,56*	7,56	Month 2	48,25	63,86	15,61	19,57
Month 3	167,40	173,52	6,12	7,56	Month 3	113,75	122,07	8,32	19,57
Month 4	201,60	217,22	15,62*	7,56	Month 4	189,69	213,78	24,08*	19,57
Month 5	228,52	231,30	2,78	7,56	Month 5	248,28	285,19	36,92*	19,57
	P2	P3				P2	P3		
Month 1	89,52	93,06	3,54	6,32	Month 1	14,96	16,66	1,70	16,38
Month 2	137,96	141,54	3,58	6,32	Month 2	59,09	63,86	4,74	16,38
Month 3	170,10	173,52	3,42	6,32	Month 3	117,96	122,07	4,11	16,38
Month 4	207,44	217,22	9,78*	6,32	Month 4	208,45	213,78	5,33	16,38
Month 5	217,38	231,30	13,92*	6,32	Month 5	238,01	285,19	47,19*	19,57

*: Significant value at 0.05; DMS: Tukey's Least Significant Difference.

Table 9

Tukey's test to determine significant differences month by month, in each treatment, between the mean lengths and weights of Oreochromis spp., in polyculture at three planting densities with C. macropomum in an intensive system, march - july 2014.

Length					Weight				
Time	P1		Diference	DMS	Time	P1		Diference	DMS
Month 1- Month 2	87,52	127,98	40,46*	8,29	Month 1- Month 2	11,74	48,25	36,51*	21,47
Month 2- Month3	127,98	167,40	39,42*	8,29	Month 2- Month3	48,25	113,75	65,50*	21,47
Month 3- Month 4	167,40	201,60	34,20*	8,29	Month 3- Month 4	113,75	189,69	75,95*	21,47
Month 4- Month 5	201,60	228,52	26,92*	8,29	Month 4- Month 5	189,69	248,28	58,59*	22,83
	P2					P2			
Month 1- Month 2	89,52	137,96	48,44*	8,29	Month 1- Month 2	14,96	59,09	44,14*	21,47
Month 2- Month3	137,96	170,10	32,14*	8,29	Month 2- Month3	59,09	117,96	58,87*	21,47
Month 3- Month 4	170,10	207,44	37,34*	8,29	Month 3- Month 4	117,96	208,45	90,49*	21,47
Month 4- Month 5	207,44	217,38	9,94*	8,29	Month 4- Month 5	208,45	238,01	29,56	19,57
	P3					P3			
Month 1- Month 2	93,06	141,54	48,48*	8,29	Month 1- Month 2	16,66	63,86	47,20*	21,47
Month 2- Month3	141,54	173,52	31,98*	8,29	Month 2- Month3	63,86	122,07	58,21*	21,47
Month 3- Month 4	173,52	217,22	43,70*	8,29	Month 3- Month 4	122,07	213,78	91,71*	21,47
Month 4- Month 5	217,22	231,30	14,08*	8,29	Month 4- Month 5	213,78	285,20	71,42*	21,47

*: Significant value at 0.05; DMS: Tukey's Least Significant Difference.

Table 10
Monthly increases in mean lengths and weights of Oreochromis spp., in polyculture at three planting densities with C. macropomum in an intensive system, march – july 2014.

Time	Pond 1			Pond 2			Pond 3		
	n	Lt (mm)	Wt (g)	n	Lt (mm)	Wt (g)	n	Lt (mm)	Wt (g)
S-M1	470	63,22	11,51	560	65,22	14,73	512	68,76	16,43
M1-M2	50	40,46	36,51	50	48,44	44,13	50	48,48	47,20
M2-M3	50	39,42	65,50	50	32,14	58,87	50	31,98	58,21
M3-M4	50	34,20	75,94	50	37,34	90,49	50	43,70	91,71
M4-M5	50	26,92	58,59	50	9,94	29,56	50	14,08	71,42

3.3 Production Yield

Total productions increased with the increase in population density: 119.74 kg for Pond 1 (10.00 kg of gamitana and 109.74 kg of hybrid tilapia), 139.67 kg for Pond 2 (16.86 kg of gamitana and 122.74 kg of hybrid tilapia) and 155.14 kg for Pond 3 (20.53 kg of gamitana and 134.61 kg of hybrid tilapia). Gross and net productions followed the same trend, being higher in Pond 3: 12,120.70 kg/ha and 10,837.44 kg/ha, respectively.

3.4. Feed Conversion Factor

The feed conversion factors reached low values: 0.95 in Pond 1 (5.5 fish/m2), 1.23 in Pond 2 (6 fish/m2) and 1.11 in Pond 3 (6.5 fish/m2). As can be seen, the best conversion factor corresponded to a total density of 5.5 fish/m2.

3.5 Weight Length Ratio

The weight-length equations were determined for the two species in each treatment (Table 11) and when comparing them through the analysis of covariance (Table 12), it was possible to establish that there were significant differences between regressions for gamitana and between regressions, slopes and origins for hybrid tilapia.

Table 11
Parameters of the weight-length relationship, comparative allometric condition factor and t-test for exponent b of C. macropomum and Oreochromis spp in polyculture with three planting densities, in an intensive system, march – july 2014.

Ponds	Lt	Pt	r	b	a	a*	tc	tt
C. macropomum								
Pond 1	129,16	47,97	0,994	2,932	3,00E-05	1.08E-02	0,204	1,645
Pond 2	130,30	48,39	0,996	2,841	4,00E-05	1.06E-02	0,664	1,645
Pond 3	128,84	48,46	0,996	2,865	4,00E-05	1.10E-02	0,517	1,645
Oreochromis spp								
Pond 1	162,60	122,34	0,995	3,194	8,00E-06	1.34E-02	0,629	1,645
Pond 2	164,48	127,69	0,996	3,145	1,00E-05	1.35E-02	0,556	1,645
Pond 3	171,33	140,31	0,997	3,102	1,00E-05	1.30E-02	0,413	1,645

n = Number of copies; T = Witness; Lt = Average full length (mm); Pt = Average Total weigth (g); r = Correlation coefficient; a = Allometric Condition Factor; a* = Comparative Allometric Condition Factor; b = Exponential regression coefficient; t_c = t value calculated; t_t = Value of t in the tables; * = Significant value at the 0.05 level

The t test for the exponent b (Table 11), established that its values do not differ statistically from 3, in both species and in the two treatments, typifying Isometric growth in all cases.

The best value of the comparative allometric condition factor corresponded to a density of 6.5 fish/m2 in *C. macropomum* and a density of 6 fish/m2 in *Oreochromis spp*

Table 12
Analysis of covariance for the weight-length relationship of C. macropomum and Oreochromis spp in intensive polyculture at three planting densities, march - july 2014.

F Test and decision	*C. macropomun*		*Oreochromis spp*	
	Fr	Ft	Fr	Ft
FR	2,633*	2,381	12,039*	2,381
Fb	2,605	3,005	7,230*	3,005
Fa	2,633	3,005	16,572*	3,005

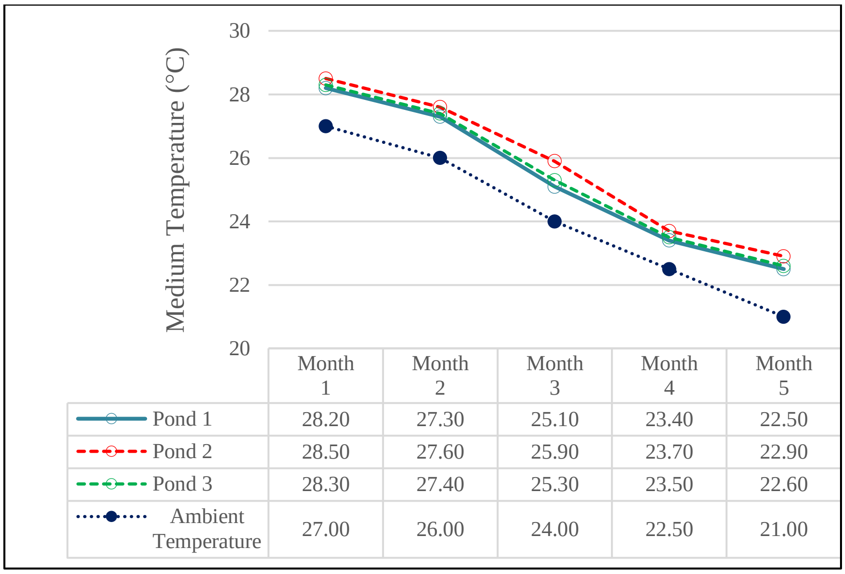
FR, Fb y Fa = F test in analysis of covariance for regression
* = Significant value at the 0.05 level.

3.6 Physical-chemical characteristics of water

3.6.1 *Temperature*

The surface temperature of the water was similar in the three treatments, with a tendency to decrease its value towards the end of the crop. The temperature values fluctuated between 22.5 and 28.5 °C (Figure 7). Meanwhile, the recorded environmental temperature was slightly lower than that of the pond water and its values decreased from 27.0 °C in the first month to 21.0 °C in the last month.

Figure 7
Variation of the average monthly environmental and water temperature of the polyculture ponds of C. macropomum and Oreochromis spp in three stocking densities, March - July 2014.

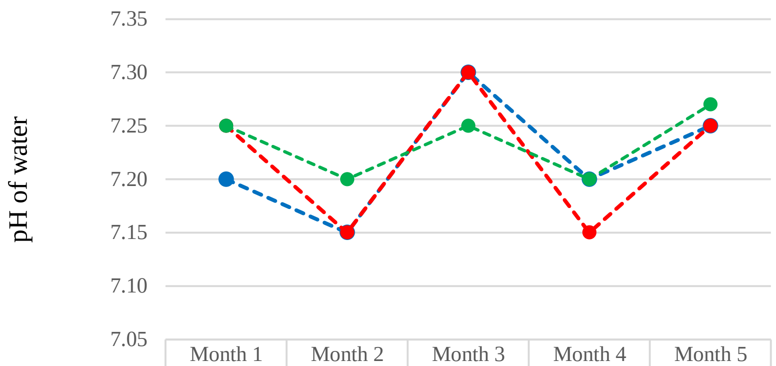


6.2 *pH*

The pH values of the water reached values that were mostly above 7 during the culture process, varying from 7 to 7.3 (Figure 8).

Figure 8

Monthly variations of pH of the water of the polyculture ponds of C. macropomum and Oreochromis spp in three stocking densities, march - july 2014.



	Month 1	Month 2	Month 3	Month 4	Month 5
Pond 1	7.20	7.15	7.30	7.20	7.25
Pond 2	7.25	7.15	7.30	7.15	7.25
Pond 3	7.25	7.20	7.25	7.20	7.27

Discussion

In observance of the results obtained at the end of the polyculture, the hypothesis proposed in the project was rejected, in the sense of greater growth of the fish in the lower population density, since in the present study it has been found that the greater growth for *C. macropomum* and. *Oreochromis spp* it was achieved in the highest total density (6.5 fish/m2), although the analysis of variance did not show significant differences for the first of those named; A fact that could be explained by the fact that in the case of an intensive polyculture with continuous water exchange, the population density would be favoring the growth of the fish, coinciding with what was found with Racchumí (2013), in intensive culture of *Oreochromis spp*. in concrete ponds, Correa and Guevara (2013) and López and Lora (2013), in intensive culture with recirculation of *Trichomycterus punctulatus* as well as with López and Lora (2014), in intensive culture with recirculation of *Dormitator latifrons*. It should be noted that although it is true, changes in the population density of *C. macropomum* did not affect its growth, this did favorably affect the growth of *Oreochromis spp*., agreeing with Acosta and Farfán (personal communication), in polyculture of *Piaractus barchypomus* and *Oreochromis spp.*

The mean lengths and weights achieved at the end of this study are lower than that achieved by Tafur et al. (2009): 434 g in 160 days of polyculture with *Chaetobranchus semifasciatus*, *P. brachypomus* and *C. macropomum*, fed with a diet of 25 % protein and total density of 1 fish/m2; which would be explained because the starting weight was higher: 25.3 g, at the lowest planting density and the longest cultivation time. Likewise, they are lower than the report by López et al. (2012), which for the Pacotana hybrid (*C. macropomum* x *P. brachypomus*) reached a weight of 293.20 g, in polyculture with hybrid tilapia (*O. niloticus var. Stirling* x *O. aureus*) and pocoche (*D. latifrons*), at a total density of 3.20 fish/m2, for six months and with a balanced diet; which would be explained by the lower planting density and longer cultivation time.

Regarding *Oreochromis spp*., the best growth obtained in the present study exceeds the report by López et al. (2012), who reached 274.50 g in polyculture with *C. macropomum* x *P. brachypomus* and D. latifrons , at a total density of 3.20 fish/m2, for six months and with a balanced diet; fact that would be fundamentally linked to the constant exchange of water carried out, which greatly favored the quality of the water. Likewise, they exceed the results of Rivera and Vega (2013), who achieved 199.20 g, in polyculture with *T. punctulatus* and *D. latifrons*, at a total density of 9 fish/m2, for six months and supplemented with purine balance. ; Cerdán and

Sánchez (2014), who obtained 230.97 g, in polyculture with *Macrobrachium inca* and *D. latifrons*, at a total density of 4.5 org/m2, for six months and fed with purine balance; López and Lora (1989a), who obtained 129.40 g for the *O. niloticus* x *O. hornorum* hybrid, in polyculture with *T. punctulatus* and *Mugil cephalus*, at a total density of 3 fish/m2, for six months and fed with rice powder; López and Lora (1989b), who achieved 153.13 g for the *O. niloticus* x *O. hornorum* hybrid, in polyculture with *T. punctulatus* and *M. cephalus*, at a total density of 3 fish/m2, for six months and purine fed for birds; and from López and Lora (1990), who reached 66.92 g for the hybrid of *O. niloticus* x *O. hornorum*, in polyculture with *T. punctulatus* and *Mugil cephalus*, with a feeding index of 2.5 % of rice dust. , in the total density of 3 fish/m2, for six months; which would also be due to the reasons already exposed above.

The fact that the Tukey test has determined that the growth of gamitana is significant only in the first month of cultivation, would indicate that they have reached the asymptotic level of growth; however, this would not be the case, but would be basically influenced by the decrease in temperature below the optimum level for its growth. In contrast, hybrid tilapia showed significant growth throughout the culture process, indicating that it has not yet reached the asymptotic level of its growth.

The increase in total, gross and net productions with the increase in stocking density was due to both the greater population of the ponds and the greater growth experienced by the fish in these treatments.

The best feed conversion factor corresponded to a density of 5.5 fish/m2 (Pond 1), where the yield was lower; however, it differed very little from the density of 6.5 fish/m2 (Pond 3), which reached the highest yield, which was probably due to the fact that a slight excess of food would have been delivered in this last treatment. Likewise, these feed conversion factor values were found to be below the range of 1.2 to 1.5 for "Tilapia" (Pineda, 2012) and 1.5 to 2.0 for gamitana (Eufracio and Palomino, 2004). ; likewise they are below the international order of 1.3 to 1.7 (Negret, 1993). It should be noted that the conversion factors achieved in the three treatments are low and similar to those achieved by Cerdán and Sánchez (2014): 0.94 (4.5 org/m2), 1.16 (5.5 org/m2), 1.18 (6.5 org/m2) and 1.05 (7.5 org/m2), in polyculture of *M. inca*, *D. latifrons* and Oreochromis spp. and better than those achieved by Rivera and Vega (2013): 1.52 (7 fish/m2) and 1.22 (9 fish/m2), in polyculture of *T. punctulatus, D. latifrons* and *Oreochromis spp.*

The analysis of covariance, when determining significant differences between its parameters, evidenced the effect of the stocking density on the growth of hybrid tilapia and corroborated the results of the analysis of variance; however, it did not coincide for gamitana where the analysis of variance determined that there are no significant differences in growth, and it should be noted that the differences between the weight-length equations were only manifested between regressions, but not between slopes and origins.

Regarding the comparative allometric condition factor, its highest value coincided with the best growth observed for gamitana; On the other hand, for hybrid tilapia, this did not occur, since it occurred in the treatment where they grew less (Pond 2).

On the other hand, the fact of typifying isometric growth for the two species in the three treatments would coincide with the results of the analysis of variance for the case of gamitana; but not for hybrid tilapia where significant differences in growth were evidenced, indicating that this is relative because through the analysis of covariance it was determined that the values of b differ statistically between treatments.

The variations of the surface water temperature of the culture ponds, with the tendency to decrease their values as the polyculture passed, obeyed the seasonal changes that its execution covered (march-july): Summer-Autumn- Winter; however, they were found within the levels considered for tilapia culture, which according to Huet (1998), is between 20 and 30°C, and they were also in the range of 20oC to 28oC, considered adequate for tropical fish farming by Boyd (1990).). On the other hand, the temperatures recorded, in the case of *C. macropomum*, only in the first three months were within the range of good growth for this species, which is between 25 and 30 °C (Eufracio and Palomino, 2004), in Instead, they were below the lower limit in the final two months, which would have affected their growth, which was very low.

The pH values of the pond water were found within the optimal growth range for *C. macropomum*, which according to Eufracio and Palomino (2004), is between 7 and 8; likewise, they were between 6.5 and 9 considered optimal for fish production (Boyd, Op. cit.); likewise, they are slightly alkaline waters which, according to Huet (Op. cit.), are the best fish waters.

Conclusions

1. The stocking density positively affected the growth of *C. macropomum* and *Oreochromis spp*., being higher in the density of 6.5 fish/m2.
2. The best production performance corresponded to the highest density (6.5 fish/m2).
3. The weight-length relationship and condition factor evidenced the effect of planting density on growth

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