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INTENSIVE REARING OF JUVENILES OF *CICHLASOMA MANAGUENSE* (GÜNTHER 1869) IN RECIRCULATED SYSTEMS

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ABSTRACT

The growth performance of guapote juveniles in recirculated systems from spawning to a mean weight of about 3 gramms is described. Culture began with a 15-days nursing phase with either first instar-nauplii or fresh decapsulated cysts of Artemia followed by artificial diet. Regression models are given for various growth and dispersion parameters. The growth performances with Artemia nauplii or cysts in the nursing phase are compared.

RESUMEN

Se describe la cría de juveniles de guapote tigre en sistema recirculado desde el inicio de la alimentación hasta los 3 gramos de peso promedio. Se comenzó con una fase nodriza de 15 días en que se alimentó con nauplios o cistos decapsulados de Artemia seguida de alimentación artificial. Se calculan para ambas fases de crecimiento modelos de regresión para diversos parámetros de crecimiento y dispersión. Se comparan los crecimientos obtenidos con nauplios o cistos en la fase nodriza.

INTRODUCTION

The guapote tigre (*Cichlasoma managuense* Günther 1869), is an autochthonous piscivorous cichlid ranging from Costa Rica to Honduras (VILLA 1984, BUSSING 1987). This species has been recommended (DUNSETH and BAYNE 1979, LOVSHIN 1980) and is regularly used as recruitment controller in extensive tilapia ponds in several Central American countries (COPESCAL 1984, 1986). In Costa Rica however, there is often a shortage in the supply of guapote juveniles, mainly because this species sticks its eggs to a carefully cleaned hard substrate and thus will not spawn in tilapia ponds with muddy bottoms.

In laboratory tanks this species reproduces easily with spawnings of 2.000 to 6.000 eggs per female of 250 to 400 g. Within the scope of an investigation program on growth and nutrition of the guapote, we have produced in recirculated water systems in our laboratory routinely, during several years, thousands of juveniles of guapote tigre. This paper describes the methodology and the results of this intensive raising system.

MATERIAL AND METHODS

ANIMALS. Five batches (1.741 to 4.936 larvae each) spawned in a 2.000 liter tank with 5 adult pairs were reared to an age of 40 to 80 days. Larvae were siphoned out as wigglers (moving yolksack larvae on the bottom before freeswimming) 4 to 5 days after spawning and brought to a 200 liter aquarium. Feeding began the first day after free swimming, which counts as day 1.

RECIRCULATED UNITS. For the first 20 days a 200 l aquarium was used, recirculating water at a rate of 1 to 2 l/min through a biological filter containing. Afterwards the larvae were brought to a 2.000 l tank. Water temperature was maintained between 26 to 30 °C with a floating heater of 1.500 watts. Water mixing in the tank was achieved with a 5 inch air-diffuser. A small amount of fresh-water was continuously added to control nitrite levels during the last phase of the culture period. Feed rests and faeces were siphoned out daily at 8 am. Dissolved oxygen, temperature and nitrite were

measured daily at 8 am and 6 pm. Ammonia and pH were controlled weekly. Light cycle was 13:11, with light period between 6 am and 7 pm.

FEEDS AND FEEDING. Larvae of 3 spawns were fed, during a 15 days nursing period, with fresh decapsulated Artemia cysts (decapsulation with commercial chlorine, cysts dry weight 3 µ g) (treatment C(ysts)). During the same nursing period, larvae from the 2 other spawns were fed with first-instar nauplii (hatching time 24 hours, nauplius dry weight 2.3 µ g) (treatment N(auplii)).

Feed was given, after preliminary experiments, at maximum ration, taking as basis a growth coefficient g (VERRETH *et al.*, 1987) of 0.2 and a dry feed conversion of 3. Feed ration was however adjusted daily by observation of satiation behaviour, and was adjusted further every 3 to 5 days to the dry weight of the larvae. Feed was given 5 to 7 times a day, stirring up every time cysts or nauplii from the aquarium bottom.

After the nursing period the larvae were gradually weaned to an artificial diet (Table I) during a 4 day period (days 16-19), increasing progressively the ratio artificial diet/natural food. At day 20 of the experiment the larvae were transferred to the 2.000 l tank and fed 5 times a day. Feed was given again at maximum ration, assuming at begin a metabolic ration (R_m) of 20 g/Kg$^{0.8}$/day and a feed conversion (FC) of 1.2. The model was readjusted every 1 to 2 weeks diminishing R_m if the FC increased over 1.2.

DATA. During the nursing period, samples of about 20 fishes each were weighed every 3-4 days (wet and dry weight). Thereafter, samples of about 200 fishes were weighed individually every 1 to 2 weeks. All fish were returned to the tank, with the exception of a few animals, used to measure dry weight. The following variables were recorded or calculated for every sampling period: Mean weight Wx, maximum weight Wmax, coefficient of variation CV, coefficient of asymmetry SK, mortality M, actual metabolic feeding level Rm in g/Kg$^{0.8}$/day, specific growth rate SGR (SGR = (LN Wx_{final} - LN $Wx_{initial}$)*100/t days) in % body weight/day, apparent feed conversion FC (dry feed/fresh weight increase), growth coefficient g (g = ($Wxf^{(1/3)}$-$Wxi^{(1/3)}$)/t). All fishes of the tank were counted every 3 to 4 weeks.

Data were analyzed through regression analysis using the software package STATGRAPHICS. Statistical differences between pooled data from 3 variables (g, Rm and FC) from the nursing period and the first 20 days of artificial feeding, were analyzed through Student t-tests.

RESULTS

WATER QUALITY. The water quality changed throughout the culture period because of increasing biomass and increasing fresh water supply. Mean temperature decreased with increasing fresh water supply from about 30 °C at the begin to 26 °C at the end of the culture period, with a daily variation of about 1 °C (higher at evening). Mean dissolved oxygen decreased from about 6 ppm at beginning to 4 ppm at the end of the culture period. Daily variation in DO levels increased gradually from 0.0 to 1.5 ppm during the culture period, with lower values at 6 pm. The mean nitrite level reached 0.3 ppm at the end of the nursing phase, decreased again to 0.1 after transfer to the tank and reached again 0.4 ppm at the end of the culture period.

TABLE I

COMPOSITION OF ARTIFICIAL DIET

Ingredients		*Proximate analysis*	
Fish meal	47.6 %	Protein	50 %
Soybean meal	10	Carbohydrates	15
Blood meal	15	Lipids	15
Tankage	5	Ash	18
Corn meal	10		
Soybean oil	5.4		
Fish oil	4		
Salt	1		
Vitamin premix[1]	1		

Diet was pelletized with 0.5, 1 and 2 mm pellet diameter, kept at -22 °C and used as moist pellets with 40 % humidity.

1. Vitamin premix (per Kg): A 800000 UI, D 200000 UI, E 10 g, K 1 g, B1 2 g, B2 3 g, B5 15 g, B6 2 g, B12 2 mg, H 500 mg, C 200 g, Folic acid 1 g, Niacin 20 g, Choline 100 g.

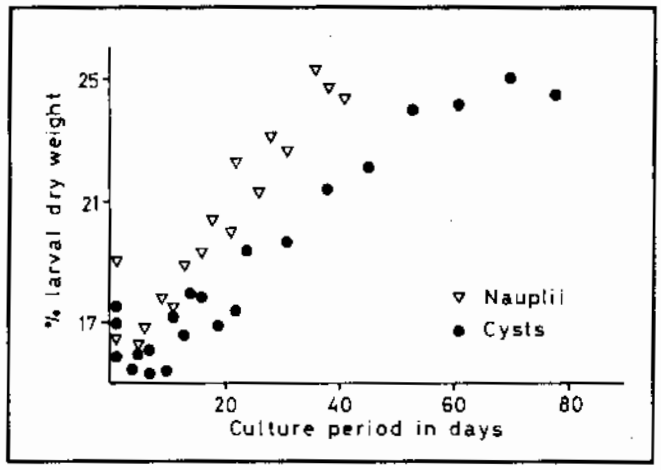

Figure 1.
Dry weight of guapote larvae in % fresh body weight with increasing age in days. Triangles and points refer to animals reared in the nursing period of 15 days with first-instar Artemia nauplii vs. fresh decapsulated Artemia cysts.

PATHOLOGY. Immediately after weaning two cohorts of treatment C showed symptoms of fin rot. Mixobacteria were present at infected sites. The infection was not treated and lasted about 1 week. One of these cohorts was also infected when 70 days old by *Gyrodactylus*. The parasitosis was noticed after one week, when infection was rather heavy, but could be succesfully treated with Trichlorfon at 0.5 ppm for 24 hours. Mortality was about 3 %.

MORTALITY. In two culture trials with cysts-fed larvae, Flexibacter infections caused about 14 % mortality in one week. Correcting the data for Flexibacter caused mortality, the total mortality rate increased at 0.23 ± 0.06 %/day (CL 95 %), showing no difference between treatments. Table II gives the initial and final numbers of guapote larvae in all trials.

LARVAL DRY WEIGHT. Figure 1 shows the dry weight increase during the culture period. Mean dry weight as % of fresh weight at day 1 was 17.2 ± 1.6 % (95 % CL), decreased somewhat during the first days (mean value of days 2-10: 16.15 ± 1.1% (95 % CL), not significant different from initial value) and increased thereafter to about 25 % between days 40 and 80. The increase was apparently more rapid for treatment N than for treatment C.

MEAN LARVAL WEIGHT. The mean larval weight at day 1 before feeding was 3.6 ± 0.53 mg (95 % CL). Figure 2 shows the increase in mean weight for both treatments. The weight parameters (mean and maximum weights) were fitted by exponential expressions based on the model «g» (HOGENDOORN 1980, y = ((a)^(1/3)+g*t)^3)/1.000) taking as value «a» the mean initial fresh weight of 3.7 mg (Table II). Juveniles of treatment C attained after 80 days culture a mean weight of 2.2 g (g-value = 0.14) and maximum weights around 5.7 g (g-value = 0.20). The weight increase was significantly greater for nauplii-fed juveniles, which after 40 days culture attained a mean weight (0.66 g, g-value = 0.18) more then two times higher than that of cysts-fed fishes (0.31 g), while the maximal weights (0.897 g, g-value 0.21) were still about 1.2 times higher (0.897 vs. 0.75 g).

DISPERSION PARAMETERS. Both the coefficient

TABLE II

INITIAL AND FINAL NUMBERS OF GUAPOTE LARVAE IN ALL TRIALS

Treatment	*Day*		
	1	*40*	*80*
	$4655_{1,2}$	3659	2921
Cysts	4708	4299	3969
	4239_{1}	3412	3057
	4936	4318	
Nauplii	1741	1511	

1: Trial with Flexibacter infection, 2: Gyrodactylus infection.

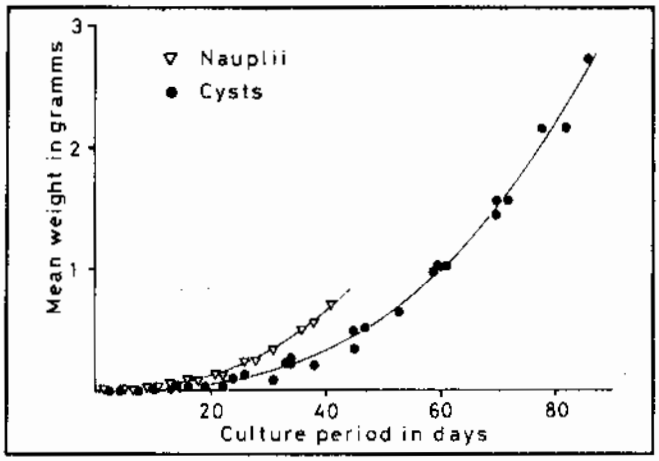

Figure 2.
Increase of mean weight of guapote larvae with increasing age in days. Meaning of triangles and points as in Fig. 1. Regression lines for both treatments correspond to the models of Table III.

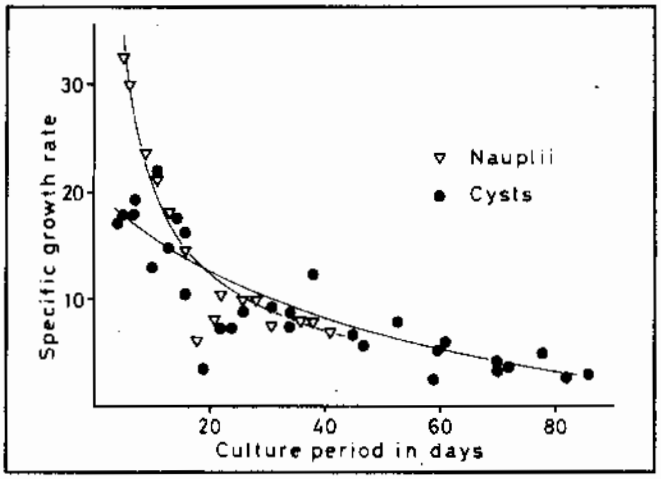

Figure 3.
Decrease of specific growth rate of guapote larvae in % fresh body weight per day with increasing age. Meaning of triangles and points as in Fig. 1. Regression lines for both treatments correspond to the models of Table III.

of variation and the coefficient of asymmetry (skewness) increased with age, without detectable differences between both treatments. The pooled coefficient of variation could be reasonably fitted by a linear equation (Table II) increasing from about 10% at day 1 to 45% after 80 days. The pooled skewness showed a much greater variability and could be best fitted by a quadratic relation (Table II) reaching values over 1.0 at the end of the culture period.

GROWTH PARAMETERS. The mean specific growth rate (SGR) decreased rapidly with age in both treatments (Figure 3). In cysts-fed juveniles the SGR decreased from about 20 % at day 5 to about 3.5 % at day 80. Around day 20, abnormal low values in growth rate can be observed, which coincide with the transition from natural to artificial feed. If those values are not considered, the SGR of both treatments show a continuous behaviour and are well fitted by exponential models (Table II). While the predicted SGR are similar for both treatments in the diet-feeding period, in the nursing phase the SGR is much higher for the nauplius-fed than for the cysts-fed larvae.

Figure 4 shows the values of the growth parameter g, the metabolic feed ration (RM) and the apparent feed conversion (FC) over the whole culture period for both treatments. While g decreases continuously with age (apart from the diet transition period with a temporary decline), RM and FC show both a sharp momentaneous increase at the onset of artificial feeding. The mean FC did not change

TABLE III

INTENSIVE CULTURE OF GUAPOTE JUVENILES. REGRESSION MODELS

Regression model	r^2
Wx/C = ((1.55 + 0.144 * t) ^ 3)/1000	0.99
Wx/N = ((1.55 + 0.177 * t) ^ 3)/1000	0.99
Wmax/C = ((1.55 + 0.203 * t) ^ 3)/1000	0.96
Wmax/N = ((1.55 + 0.210 * t) ^ 3)/1000	0.97
CV = 11.452 + 0.4076 * t	0.84
SK = 0.2005 + 0.000171 * t ^ 2	0.55
SGR/C = 20.0 * e ^ (-0.0235 * t)	0.95
SGR/N = 33.1 * e ^ (-0.042 * t)	0.93
RM = 21.33 * e ^ (-0.0057 * t) (20 < t < 80)	0.45

C, N: treatment C and N, t: time in days, Wx: mean fresh weight in gramms, Wmax: maximum weight in gramms, CV: coefficient of variation, SK: coefficient of asymmetry, SGR: mean growth rate in % body weight/day, RM: metabolic ration in gramms/ metabolic weight/day.

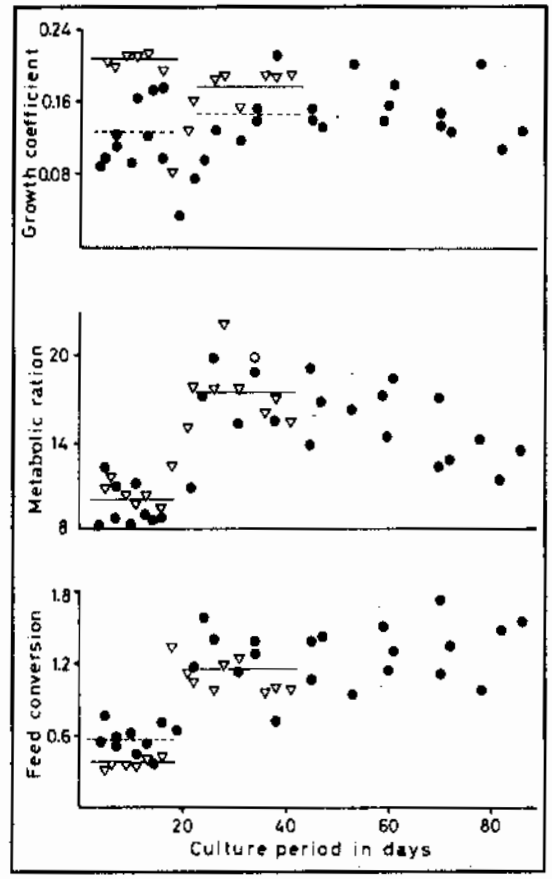

Figure 4.
Changes of growth coefficient g, metabolic ration Rm and apparent feed conversion FC of guapote larvae with increasing culture period. Meaning of triangles and points as in Fig. 1. Continuous (triangles) and interrupted (points) lines represent the mean values of nursing and first postnursing (artificial diet) period, as calculated in Table III. Only one continuous line is drawn when there is no statistical difference between both treatments.

further until day 80 (mean value 1.2). On the contrary RM decreased slowly with time and is best fitted by an exponential regression model (Table II).

Since the parameters of figure 4 do not change rapidly with time, they can be used to compare the growth performance of both treatments (days 1-20: Artemia period, cysts vs. nauplii, days 20-45: early diet period) by Student T-tests between the corresponding mean values. Table III and Figure 4 show the result of this analysis.

The RM was significantly higher when feeding artificial feed (17.35) than when feeding Artemia (10.1). The RM for artificial diet was the same after both Artemia-treatments (17.3 vs 17.4) and there was neither a statistically significant difference between RM while feeding cysts or nauplii.

The FC was significantly higher with artificial feed (mean 1.16) than with Artemia (mean 0.48). Both treatments had similar FC in the artificial diet period (1.23 vs. 1.08), but the FC was statistically lower with nauplii (0.38) than with cysts diet (0.57).

The growth coefficient g increased little (but not significantly) during treatment C from the Artemia to the diet period (0.129 vs. 0.149), but decreased significantly in the nauplii-fed juveniles from 0.208 in the Artemia period to 0.176 in the pellet diet period. In both periods the growth coefficient of nauplii-fed larvae was significantly higher than that of cysts-fed juveniles.

DISCUSSION

The use of decapsulated Artemia cysts as larval food has increased in recent years because of their advantages over instar I-nauplii: lesser size, higher energy content, relative ease to handle and produce (LEGER *et al.*, 1987). BRUGGEMAN *et al.* (1980) report good growth of the larvae of *Chanos chanos*, *Lebistes* and *Xiphophorus* with decapsulated cysts, and they take for granted that cysts will be at least as good a food as freshly hatched nauplii for *Penaeus* and *Macrobrachium* larvae. VERRETH *et al.* (1987) proved for *Clarias* larvae that dry decapsulated cysts were superior to shock frozen nauplii.

Our results show that the larvae of *Cichlasoma managuense* can be grown on decapsulated cysts, but that the growth performance is significantly lower than with living nauplii: 60 % of the specific growth rate and 150 % of FC of nauplii-fed larvae. The dry weight of nauplii-fed larvae increased faster than that of cyst-fed fishes. The spontaneous Flexibacter infections in two cysts-fed cohorts may also reflect a somewhat impaired physical condition.

More than the nutritional value of both cysts and nauplii, which is even slighty higher in cysts (LEGER *et al.*, 1987, VERRETH *et al.*, 1987), other, circumstantial factors are probably responsible for the different growth performance. VERRETH *et al.* (1987) attributed the superior cysts performance in *Clarias* larvae to the flotability of dry cysts and to their smaller size. Since guapote larvae are well able to capture first instar nauplii (MEYER 1987), the smaller size of the cysts is probably not important in our case. On the other hand, while guapote larvae also ingest inert objects, they prefer moving objects over non moving ones (MEYER 1987), and this makes probably the difference between inert cysts and moving nauplii. Because normally only a small fraction of the guapote larvae are feeding on the bottom, the higher sinking velocity of fresh decapsulated cysts as compared to moving nauplii will also impair the feeding response of the guapote.

The transition from live food to artificial diet proved to be a critical period. At this time our guapote larvae of about 40 to 50 mg weight were well able to ingest 0.5 mm soft pellets, but growth was always severely impaired in the transition

TABLE IV

COMPARISON OF GROWTH PERFORMANCES IN THE NURSING PERIOD AND IN THE EARLY DIET PERIOD

	Coefficient G			*Metabolic Ration*			*Feed Conversion*		
	Nursing period		*Diet period*	*Nursing period*		*Diet period*	*Nursing period*		*Diet period*
Cysts	0.129	NS	0.149	9.5	**	17.4	0.57	**	1.23
	**		*	NS		NS	**		NS
Naupl.	0.208	**	0.176	10.6	**	17.3	0.38	**	1.08

NS: no significant, **, *: $P < 0.05$, $P < 0.1$: T-tests between mean values on both sides.

period of 4 days. The transition was harder for the cysts-fed larvae, as may be seen from the *Flexibacter* infections and from the fact that in the first days of artificial diet the growth rate was always higher in nauplii-fed than in cysts-fed larvae. It is suggested to increase the period of transition to at least one week, while giving together natural and artificial food.

It is believed that growth in the last two or three weeks of our culture period was well below the possible growth performance of guapote juveniles. Fishes taken to other facilities and isolated showed again growth rates of over 7% (unpublished observations), as compared with 3.5 % after 80 days in our rearing facility. In the last period growth was probably hampered by the deteriorating water quality as well as rapidly increasing density effects (SACLAUSO 1985, GÜNTHER and GALVEZ 1989), as may be inferred from the quadratic increase in skewness, which points to strong competition effects.

Cichlasoma managuense is a relatively small fish (maximum weight about 1.5 Kg, VILLA 1984, BUSSING 1987), so high growth rates can hardly be expected. In the larval phase the maximum g of about 0.2 is notably lower than values reported for common carp (BRYANT and MATTY 1981: 0.25), *Clarias gariepinnus* (HECHT 1987: 0.32) and *Colossoma macropomum* (0.5, unpublished observations), but compare favourably to those of different tilapias (TACON 1983, 0.14 in *T. nilotica*, MACINTOSH 1985, 0.18 in *T. mossambica*, SACLAUSO 1985, 0.13 in *T. zilli)* measured under similar conditions.

In the range between 100 mg and 1.5 g the mean SGR of the guapote under our culture conditions (5.5 %) is slighty lower than that reported for some tilapias (PRICE 1985, 6.9 % in *T. mossambica*, and 6.9 % in *T. melanotheron*, DESILVA 1985, 3.5 % in *T. nilotica)*, but it must be taken into account that the conditions for growth in our setup were not optimal during the last weeks.

We can conclude that juveniles of *Cichlasoma managuense* can be adequately reared until a weight of about 1.5 g in recirculated systems, while fed with Artemia cysts or nauplii during a first nursing phase of 15 days followed by an artificial diet. The rearing facilities are simple, inexpensive and easy to build, so this method can help to solve the problem of obtaining guapote juveniles for culture.

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