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# Growth and feed utilization of Dow cichlid (*Cichlasoma dovii*) larvae fed Artemia nauplii

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**Abstract:** Growth and feed utilization of Dow cichlid larvae (*Cichlasoma dovii*) fed with Artemia nauplii during the first 12 days are assessed and compared with the growth of the larvae of the jaguar cichlid (*Cichlasoma managuense*). Growth and feed utilization of both species are very similar, albeit slightly more advantageous in the Dow cichlid larvae. The larvae of *C. dovii* have however, a significantly greater initial weight (6.65 vs. 3.84 mg) and initial percentage dry weight (21.0 vs. 16.7 %). The data are compared to those of *Cichlasoma managuense* with regard to their ecological status.

**Key words:** Growth, feeding ecology, fish larvae, Cichlidae.

The Dow cichlid (*Cichlasoma dovii*) is a Central American piscivorous fish distributed between Honduras and northern Costa Rica (Bussing 1987). It is one of the largest cichlids in the Americas, attaining sizes of up to 7 kg in weight and 700 mm in length (Villa 1982, Aldave 1985, Sands 1986, Campos 1986, Bussing 1987). In Costa Rica it is an important game fish with excellent flesh quality (Vincenzi and Camacho 1974). It holds a small commercial fishery in the Arenal reservoir (Campos 1986). However, in recent years, its numbers have rapidly decreased probably because of overexploitation (Campos 1986). Recently, there has been an increasing interest in controlled reproduction and larval rearing with the aim of restocking natural waters (Ruiz 1994).

Biological data on the Dow cichlid are still relatively scarce. Taxonomic data are given by Moya 1979, Villa 1982 and Bussing 1987. Larval development and morphology have been described by Cabrera *et al.* (1988). Ecological aspects such as habitat preferences (Astorqui 1971, Barlow 1976, Bussing and López 1977, McKaye 1977), reproductive habits (McKaye 1977), feeding habits and growth in natural habitats (Aldave 1985) have been occasionally addressed but are still very incomplete.

The smaller cousin of the Dow, the also piscivorous jaguar cichlid, *Cichlasoma managuense*, is being used in aquaculture (Dunseth and Bayne 1978, Teichert-Coddington 1994) and aspects of reproduction and larval rearing have been thoroughly studied (Günther and Boza 1991, Günther *et al.* 1992). The aim of this paper is to characterize the growth of Dow cichlid larvae fed with Artemia nauplii during 12 days after yolk absorption, and to compare it with the jaguar cichlid data.

## MATERIAL AND METHODS

**Experimental facility**: A 20-aquaria recirculating system (aquarium volume 15 l) with sedimentator, biological filters, heating and oxygenation was used.

**Fish**: Two experiments were run with two spawns, obtained spontaneously 9 months apart from the same parents kept in a 2000 liter tank. The larvae were separated from the parents about 5 days after spawning and kept apart until the third day after free swimming, when the experiments began. The average initial weights were 6.11 and 7.18 mg, respectively, and the stocking densities 80 and 88 fish per aquarium, respectively.

**Water parameters**: The water quality was alike in both experiments. Mean water temperature (range) was 28.3°C (25 to 31° C), mean dissolved oxygen (range) was 6.4 ppm (6.0 to 6.8 ppm). Nitrite levels were always below 0.05 ppm.

**Feed**: First instar Artemia nauplii (San Francisco Bay brand) were obtained daily by hydration and incubation at 28°C during 24 h. The hatchlings were washed and kept for one day with oxygenation in the refrigerator in 18 ppt salt water. Naupliar dry weight was determined as 2.28 and 2.37 μg, respectively, in the two experiments.

Daily feeding rations were calculated with the following equations by the method described by Günther *et al.* (1992):

Growth coefficient G = (Wf^(1/3) - Growth = Wf - WiWi^(1/3))/ t

Feed conversion FC = Daily feed ration/Daily growth,

where Wi, Wf are initial and final weight in mg, respectively and t the number of days of the period.

The first experiment had six, the second, seven replicated treatments (feeding rations), calculated with assumed growth coefficients distributed in the range between G = 0.0 (fasting) to G = 0.4 (maximum feeding).

**Chemical analyses**: Proximate analyses were performed on a third spawn of *C. dovii* in duplicate, following the methods of Osborne and Voogt (1986).

**Experimental procedures**: Both experiments were run for 12 feeding days. Day 1 was the first feeding day, 3 days after free swimming. The initial parameters (larval fresh weight and percent dry weight) were determined from samples of 30 larvae from the same spawn. At days 4, 7, 10 and 13 five larvae were sampled from each aquarium before the day's first feeding and fresh and dry weight determined. The fresh weight of the larvae was determined individually after short blotting. The dry weight was determined after drying the 5 larvae for 3 h at 105° C.

Fish were fed 4 times a day with *Artemia* nauplii suspensions of known concentration. The water flow through the aquaria was suspended during feeding and about 30 min afterwards. Faeces and uneaten food were siphoned out daily and dead larvae removed several times a day.

**Data analysis**: The following parameters were analyzed for the entire period: Weight increment on fresh and dry basis (mg/period), feed conversion on wet and dry basis, specific growth rate (SGR, %body weight/day) and growth coefficient G (Günther *et al.* 1992). In addition, protein efficiency ratio (PER) was estimated:

PER = growth in weight/protein in ration.

Since both experiments were carried out under very similar conditions, all data (n = 20) were pooled together and analyzed by nonlinear regression techniques using the software STATGRAPHICS 4.0. Two outliers (negative values) had to be dropped in the analysis of the feed conversions.

Growth and feed utilization parameters were related to total dry ration by exponential expressions (Kiorboe 1989, Günther *et al.* 1992)(Table 2).

## RESULTS

**Mortality**: In all fed aquaria the final mortality was very low, ranging from 0 to 1.3%. In the second experiment the mortality of the nonfed larvae was significantly higher ($P < 0.05$) than the mortality of fed fishes, but still low with 5.12% mortality after 12 days fasting.

**Dry weight:** Figure 1A shows the dry weight as percentage of wet weight at the end of the experiments on dependence from the feeding ration. The mean dry weight increases from approximately 13% after 12 days fasting to about 20 % at higher feeding levels. The mean dry weight at the onset of the experiment

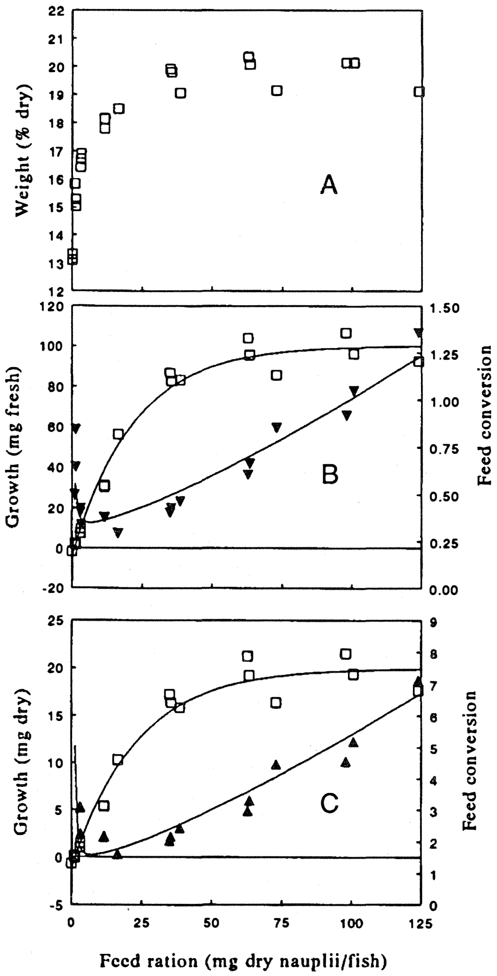


Fig. 1. A: Dry weight (in % of fresh weight) of larvae of *C. dovii* at different feeding levels. B: Growth (wet basis, empty squares) and feed conversion (wet basis, filled triangles) at different feeding levels. C: Growth (dry basis, empty squares) and feed conversion (dry basis, filled triangles) at different feeding levels. The curves represent the regression equations of table 2.

was 19.8%, only slighty lower than the maximum dry weight attained.

**Body composition:** Table 1 shows the proximate composition of *C. dovii* larvae at the beginning of the experiment and after 10 days fasting, in percentage of wet weight.

**Growth**: The growth increments on wet and dry basis are shown in Figs. 1B and 1C. The curves represent regression equations from table 2. By means of the regression equations it can be calculated that 99% of the maximum growth of 100.25 mg wet or 20.0 mg dry/per period are attained with feed rations of 99.2 vs. 105.4 mg dry nauplii/fish.

TABLE 1

*Proximate composition of* C. dovii *larvae before and after 10 days starvation, in % of wet weight*

| Component | Before | After |
|---|---|---|
| Moisture | 79.67 | 84.41 |
| Protein | 11.08 | 9.47 |
| Lipid | 6.49 | 2.26 |
| Ash | 1.59 | 2.42 |

In terms of growth rates, the maximum values were G = 0.234 or SGR = 22.54 % body weight/day.

**Feed utilization**: The values of feed conversion on a dry and wet basis are plotted in Figs. 1B and 1C, together with the curves obtained by exponential regressions. From the regression equations, minimum feed conversions and optimum rations can be calculated, both on wet and dry bases. The minimum feed conversion was 0.35 at an optimum ration of 6.38 mg dry nauplii/fish on a wet basis and 1.57 at an optimum ration of 7.15 mg dry nauplii/fish on a dry basis. The protein efficiency ratio attains a

TABLE 2

*Regression coefficients for growth and feed conversion on wet and dry basis versus total dry ration*

Growth = a*(b-exp(c*Ration))
FC = Ration/(a*(b-exp(c*Ration)))

| | Wet | | Dry | |
|---|---|---|---|---|
| Coefficients | Growth | FC | Growth | FC |
| a | 104.97 | 104.79 | 21.333 | 19.527 |
| b | 0.955 | 0.98 | 0.936 | 0.958 |
| c | -0.046 | -0.0339 | -0.044 | -0.045 |
| $r^2$ = | 0.98 | 0.85 | 0.975 | 0.96 |
| n = | 20 | 18 | 20 | 18 |

maximum of 6.1 at the optimum ration of 6.38 mg dry nauplii/fish.

## DISCUSSION

Our results confirm previous assessments (Kiorboe 1989) that fish larvae in general, at least with animal food, are particularly efficient food converters, well adapted to ensure maximum growth in this vulnerable life stage. The feed conversion values obtained for the Dow cichlid larvae are still a little more advantageous than those of the jaguar cichlid (Günther *et al.* 1992). The calculated minimum dry feed conversion of 1.57 corresponds to a gross growth efficiency of 0.63, which is near the maximum possible growth efficiency (Kiorboe 1989). However, while the experiment began 3 fasting days after freeswimming, possibly yolk reserves had not been totally absorbed, as appears from the relatively high initial dry weight. In this case growth efficiency would be overestimated. The results on growth of larval *C. dovii* are similar to those obtained for the related *C. managuense* (Günther *et al.* 1992). Some differences, however, may reflect the different ecological status of both species. In table 3 a comparison is given between the data on both species. In order to enable data comparison, maximum rations (ration for 99% of Gmax) are given as metabolic ration, $g/kg^{-0.8}/day$.

Albeit the growth coefficient G is somewhat higher in the Dow, this fish must be considered, like the jaguar cichlid, a slow grower. The growth is however somewhat higher than that reported by Aldave (1985) for a natural population of the Arenal reservoir, Guanacaste (G=0.16, recalculated).

Feed utilization values appear to be only slightly better in the Dow cichlid, while the ration for maximum growth rate, expressed in metabolic units, is similar in both species.

However, the initial weights (weight 3 days after freeswimming) are strikingly different, with the *C. dovii* larvae being about 75% heavier than those of *C. managuense*. Even with similar growth rates, this difference gives a clear advantage to the Dow cichlid larvae during subsequent growth in this critical period.

Studies about the ecological status of both *C. dovii* and *C. managuense* are scarce (Astorqui 1971, Barlow 1976, Moya 1979, Bussing and López 1977). While both species are sympatric in Costa Rica, they differ in their habitat distribution. *C. managuense* is reported as living mainly in stagnant, turbid, shallow, seasonal flood lakes of the San Juan region, characterized by high temperatures and high productivity (Bleick 1970, Astorqui 1971, Bussing 1987), while *C. dovii* is reported mainly in greater lakes and rivers with moderate currents, clear water of low productivity (Barlow 1976, Bussing and López 1977, Bussing 1987). A preference of *C. dovii* for deeper water has also been reported (Barlow 1976, Bussing and López 1977).

In the laboratory the fertility of these species is quite different. A 400 g female of *C. managuense* will produce 4000 to 6000 eggs per spawn, while a similar female of *C. dovii* produces only about 1000 eggs (unpublished observations), albeit with heavier larvae. The differences are also notorious in the dry weight of the larvae at the third day after freeswimming, 21.0 vs. 16.7% in larvae of *C. dovii* vs. larvae of *C. managuense*. This may reflect a

TABLE 3

*Comparison between growth and feed utilization of larvae of* Cichlasoma managuense *and* C. dovii

| Parameter | (units) | *C. managuense* | *C. dovii* |
|---|---|---|---|
| Initial weight | mg | 3.84 | 6.65 |
| Initial % dry weight | | 16.7 * | 21.0 ** |
| Weight 10 days | mg | 48.5 | 75.2 |
| Gmax | $mg^{(1/3)}/day$ | 0.208 | 0.234 |
| Rmax | $g/Kg^{-0.8}/day$ | 32.9 | 33.6 |
| FC wet | | 0.36 | 0.34 |
| FC dry | | 1.88 | 1.57 |

Initial: 3 days after free swimming, * mean of 3, ** mean of 4 spawns. Gmax: maximum growth rate G, Rmax: metabolic feed ration at Gmax, FC: optimum feed conversion.

relatively higher amount of yolk in the Dow cichlid larvae. Table 1 shows the proximal composition of the *C. dovii* larvae before (3 days after free swimming) and after 10 days fasting. Starvation depletes the lipid and protein stores to 35% and 85%, respectively, of the initial values in the larvae and increases the moisture content.

While the larvae of *C. managuense* showed about 85% mortality and a final dry weight of about 10% after 10 days starving, those of *C. dovii* showed only 5% mortality after 12 days fasting, with still a dry weight percentage of about 13%, thus demonstrating the greater chances of heavier larvae to survive in low productivity waters, as has been generalized also for marine fish larvae (Hunter 1984 in Osse 1992).

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## RESUMEN

Se determinan tasas de crecimiento y de utilización del alimento de larvas del guapote lagunero, *Cichlasoma dovii*, alimentadas durante 12 días con nauplios de *Artemia* y se comparan con los de larvas de guapote tigre, *C. managuense*. Ambas especies muestran valores muy similares, aunque algo más ventajosos en *C. dovii*. Las larvas de *C. dovii* muestran, sin embargo, valores de peso fresco (6,65 contra 3,84 mg) y de porcentaje de peso seco (21,0 contra 16,7 %) iniciales significativamente superiores a las del guapote tigre. Los datos se interpretan en relación con el diferente status ecológico de ambas especies de guapote.

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