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lajar@pucv.cl
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Parra-Bracamonte, Gaspar M.; Lara-Rivera, Ana L.; Sifuentes-Rincón, Ana M.; Martínez-González, Juan C.; De la Rosa-Reyna, Xochitl F.; Montelongo-Alfaro, Isidro; Moreno-Medina, Victor R.

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Research Article

Assessment of some nongenetic factors that affect egg mass weight of channel catfish, *Ictalurus punctatus*

Gaspar M. Parra-Bracamonte[1], Ana L. Lara-Rivera[2], Ana M. Sifuentes-Rincón[1]
Juan C. Martínez-González[3], Xochitl F. De la Rosa-Reyna[1,4]
Isidro Montelongo-Alfaro[5] & Victor R. Moreno-Medina[1]
[1]Instituto Politécnico Nacional-Centro de Biotecnología Genómica
Reynosa, Tamaulipas, México
[2]Instituto de Ciencias Agrícolas, Universidad Autónoma de Baja California
Mexicali, Baja California, México
[3]Facultad de Ingeniería y Ciencias, Universidad Autónoma de Tamaulipas
Victoria, Tamaulipas, México
[4]Department of Wildlife and Fisheries Sciences, Texas A&M University
College Station, Texas, USA
[5]Universidad Tecnológica del Mar Tamaulipas Bicentenario, La Pesca
Soto la Marina, Tamaulipas, México
Corresponding author: Manuel Parra-Bracamonte (gparra@ipn.mx)

ABSTRACT. Channel catfish, *Ictalurus punctatus*, is one of the most important fish species for aquaculture worldwide. Egg mass production is directly related to the success and profitability of hatchery farms assuring an adequate egg and consequently fry and fingerling quantity. Most of the success of hatchery farms in Mexico rely on the capacity of production for enough fry to cover the demand of grow-out farms. An analysis was performed with the purpose of estimate the effect of year, month, color, pond and water temperature on egg mass weight data (EMW, g) (n = 3201). The overall mean for EMW was 683.21 g. The effect of all assessed factors was highly significant ($P < 0.0001$). Pond and year effects suggested an effect possibly related to management strategies. Month indicated an important effect on early spawning, and water temperature showed a highly significant effect of gradient pattern on EMW ($P < 0.0001$), with a linear slope of -67.8 g by increasing temperature degree. Results confirmed the importance of non-genetic influence on egg mass production, supporting the need for attention of this highly variable trait and suggested the possible improvement on this reproductive indicator through the better control of environmental sources of variation.

Keywords: *Ictalurus punctatus*, environmental factors, management, spawning, temperature.

INTRODUCTION

Channel catfish, *Ictalurus punctatus*, is one of the most important fish species for aquaculture worldwide (FAO, 2015). Since the 1970´s the farming of channel catfish in Mexico, begun and developed to become one of the most important freshwater species produced under farm conditions (De la Rosa Reyna *et al.*, 2014; Lara-Rivera *et al.*, 2015).

The ability to control spawning for the production of large numbers of high-quality eggs 'on demand' (*i.e.*, all year long) may be pointed out as a primary requirement for the successful development of aquaculture (Migaud *et al.*, 2013). However, reproductive traits heritabilities are relatively variable, and for channel catfish, the few evidence may suggest the lower genetic change possible (Gima *et al.*, 2014). Although some genetic variation has been reported among strains (Broussard & Stickney, 1981), the evidence supporting the non-genetic sources of variation is more frequent than those of genetic origin are.

Since productive improvement involves the recognition of main sources of variation in order to identify the relative importance of the prevalent factors; the analysis, planning, and implementation of management strategies considering this output may produce significant improvement in the trait mean, hence the productivity of the farm.

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Most of the success of hatchery farms rely on the capacity for enough fry production to cover the demand of grow-out farms. Ever since egg mass production is an indicator of the egg count as a positive determinant of fry and fingerling production depending on the hatchability, attention must be paid to all genetic and non-genetic related variation sources.

A retrospective analysis, to assess the effect of some prevalent non-genetic factors on egg mass weight of channel catfish managed in a traditional channel catfish hatchery in Tamaulipas, Mexico was performed.

MATERIALS AND METHODS

Recorded data of egg mass weight (EMW) records from the hatchery farm "Santo Tomás S.P.R.L." was analyzed to identify the effect of some non-genetic sources of variation affecting this reproductive trait. This farm is located in Abasolo Municipality in the State of Tamaulipas, Mexico, at 24°4'N, 98°2W, 70 masl.

Hatchery management consists exclusively of breeding and the production of fry and fingerlings for commercialization. The main purpose of this farm is the production of fry and fingerlings for sale to the local, regional and national grow-out farms. Mating and spawning occur in rustic pond installations, with six-gallon buckets used as nests, and egg harvesting. The incubation (March through May) occur in hatchery troughs. The annual fry production is typically 10 million fingerlings. Fifteen ha of rustic ponds are seeded annually. Traditional reproductive management is based on selection based on conformation and size, three months before the breeding season. This selection occurs in broodstock when fish are 2 years old (with ages ranging from 1 to 3 years) and is based on size, conformation and other phenotypic traits. In general, the male: female ratio is 2:3. Conventionally, selected broodstock is from production farms of the same strain (Parra-Bracamonte *et al.*, 2011).

Data set consisted in (n = 3201) records of EMW, pond, year (2010 to 2012), month (March to May), egg mass color (yellow, brown and red) and water temperature (°C). Data were edited (data >3σ was excluded, n = 38) and normality of data was tested. A General Linear Model was fitted as: $Y_{ijklm} = \mu + Y_i + M_j + C_k + P_l + T_m + \varepsilon_{ijklm}$. Where: Y_{tijklm} = EMW; μ = overall mean; Y_i = fixed effect of i-th Year; M = fixed effect of j-th month; C = fixed effect of k-th egg mass color; P = fixed effect if l-th pond; T = fixed or covariate effect of m-th temperature; ε_{ijklm} = residual random effects. This analysis was performed by a GLM procedure. As stated temperature was either included as the covariate and fixed effect to identify differences amongst temperature degrees. Least square means and standard errors of analyzed factors were estimated. Means comparison was performed using a Tukey-Kramer adjustment test by PDIFF statement. All statistical analyses were computed in SAS 9.0 (SAS Institute Inc., Cary, North Carolina, USA).

RESULTS

The individual effect of all factors on the assessed trait was highly significant ($P < 0.0001$). The overall mean for EMW was 638.21 ± 2.38 g with a coefficient of variation of 34%, suggesting a largely variable trait affected by the influence of several factors. Model of analysis explained 38% of total variation in the trait.

The year, was estimated a significant effect ($P < 0.0001$) and the higher mean was estimated for 2010 and the lower EMW mean estimated for 2011 (Table 1). The month of spawning had a highly significant effect on EMW ($P < 0.0001$). Means indicated a gradual and significant pattern from March to May (Table 1). March with a least square mean of 866.81 g showed the higher egg mass production of -66 g and -350 g compared with April and May, respectively. Interestingly, the higher spawning month was April with 1147 records.

Egg mass color was important from the mean of yellow egg mass compared with brown and red (Table 1). Pond means are not showned; however, the effect of the pond was highly significant ($P < 0.0001$) also.

Temperature had a very important effect on EMW ($P < 0.0001$; Fig. 1). The individual effect of temperature showed a range between the 25 to 28°C classes without statistical differences, with a higher mean of EMW for spawning when temperatures were

Table 1. Effect of year, month and color on egg mass weight of channel catfish. [1]Mean with different literal among levels of the same factor are significantly different ($P < 0.05$).

Factor (*P*-value)	Level	n	LSM ± SE[1]
Year ($P < 0.0001$)	2010	954	949 ± 20.33[a]
	2011	1625	573 ± 19.4[b]
	2012	137	661 ± 30.3[a]
Month ($P < 0.0001$)	March	783	867 ± 22.2[a]
	April	1147	800 ± 20.9[b]
	May	786	516 ± 26.8[c]
Color ($P < 0.0001$)	Yellow	2472	688 ± 10.4[a]
	Brown	177	721 ± 22.3[b]
	Red	67	774 ± 39.1[b]

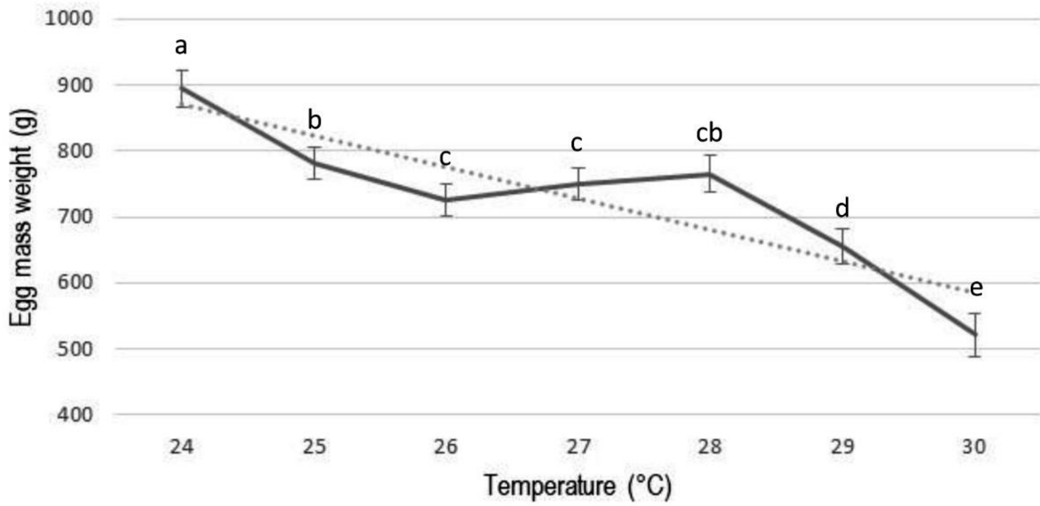

Figure 1. Effect of water temperature on egg mass weight (g) of channel catfish in a traditional hatchery. a, b, c: means with different letter are significantly different ($P < 0.05$).

lower to 25°C. Regression model fitting showed a significant slope, traduced in the reduction of -67.8 ± 3.2 g by increasing temperature degree ($R^2 = 0.1296$, $P < 0.0001$).

DISCUSSION

All factors assessed in the study are related to climatological and management elements causing variability on EMW. The found effect of the year could be related to different environmental conditions during spawning season, having a more favorable effect in 2010 compared to subsequent years. The effect of season and year on the number of eggs produced has been documented in some fish species (Kjorsvik *et al.*, 1990). It is frequent to observe variations in different years for most of the productive traits in fish. This is enhanced by direct environment influence in farming conditions.

An interesting pattern found for EMW variation, was the month of spawning, indicating possibly the most favorable month for EMW production is March. Interestingly, the most spawning frequency month was April with more than 30% egg masses than March and May. Kelly (2004) stated that in USA, the spawning season can begin in early April and last until July, but both length and start of the season is affected by water temperature. A possible explanation of this occurrence is related to temperature favorable effect on this trait, related to between-factors interactions. To briefly examine this hypothesis, an analysis including only year x month, and month x temperature interactions were assessed (data not showed). The two significantly ($P < 0.0001$) interactions strongly suggested that the best years are associated with the favorable months with better temperature ranges for spawning, producing a positive effect on EMW.

Therefore, temperature individual effect was highly associated to EMW ($P < 0.0001$), with a negative gradient towards the diminishing EMW by the degree of increasing temperature. This perhaps was the most important identified effect, because embryo development is highly influenced and vary in function of water temperature. Has been calculated that the period from fertilization and complete hatch is 6.25 days when water temperature is 26°C, with longer periods depending on water temperature reduction (Small & Bates, 2001), being the ideal temperatures between the ranges of 25.5 and 27.5°C (Tucker & Robinson, 1990; Avery & Steeby, 2004). Results suggested henceforth, that spawning season is related directly to favorable temperatures and begins early than the period reported in northern latitudes (*i.e.*, USA) (Kelly, 2004), and during a shorter period.

On the other hand, a factor directly related to management is egg mass color. Since this characteristic is associated with the embryo development stage in fertilized eggs, possibly the delays in the monitoring of nests was a direct conditioning of this color pattern occurrence. In general, this practice is made twice daily, but a reduction in personal or different external factors may affect this periodicity. With the observed trend in temperatures, this factor might be in a direct relation of May increasing temperatures, since all red egg masses were recorded in this month. This could point the importance of strict and correctly monitoring of spawning containers. Avery & Steaby (2004) indicated optimum egg checking intervals of three days for cooler temperatures, and every other day as the season progresses and water temperature increases. In this particular case with temperatures ranging the 24 to 30°C, perhaps a more convenient practice would be to check the spawning containers as frequently as possible to avoid further problems when egg masses are transferred to the hatchery for incubation.

The last evaluated factor was the pond. The significant effect of this factor on EMW may be directly related to the particular conditions of water quality and management of broodstock. No information regarding the particular conditions of water quality other than temperature was available, nor particularities of selected organisms. So many confounding factors may be interacting to affect EMW. Some aspects related to variation in pond effect were the differences in EMW with differences up to 250 g, explained in some part for reproduction ability of breeders. In practice, such a difference may result in an extra egg production of plus 5500 eggs, considering a 22,000 eggs production by egg mass average (Avery & Steeby, 2004).

Some implications of the present assessment may include the recognition of the non-genetic factors as highly important sources of variation for egg mass weight. Perhaps the most important fact here identified is the temperature effect related to year and spawning season and undoubtedly to EMW in traditional farming of channel catfish. Finally, strong attention is needed for additionally recording of factors and traits in future assessment and complementary analysis.

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