

# Survival of the prawn *Macrobrachium tenellum* (Smith, 1871) in confinement with the native fish *Dormitator latifrons* (Richardson, 1844)

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## ABSTRACT

**Objective:** The aim of this study was to test the survival of *Macrobrachium tenellum* in different confinement conditions with *Dormitator latifrons*.

**Design/methodology/approach:** Using wild specimens acclimated to captive conditions of both species, three trials of different proportion were performed with treatments consisting in the presence/absence of food and shelters. Prawn/fish proportion for the assays were: 15/15 for T1, 15/3 for T2 and 10/3 for T3. In assays T1 and T2 juvenile prawns and fish were used, while in T3 post-larvae prawns and pre-juvenile fish were used. To test the survival with or without fed, it was schedule a four-day feeding *ad libitum* period, following by a two-day fed deprivation period in all the assays.

**Results:** In assays with juveniles of *M. tenellum* the survival rate was superior to 80% with or without shelter, when T1 showed 97-100% survival; meanwhile T3 presented a 56.67 % of survival, suggesting it's necessary to use only juvenile prawns in co-culture systems. The use of shelters and fed deprivation had no significant effects on the survival of prawns.

**Limitations on study/implications:** *M. tenellum* is an important aquatic resource for the central Mexican Pacific, region in which the *D. latifrons* is a representative native fish with a developing aquaculture. A polyculture or co-culture system with these species can accelerate the sustainability of both species productions.

**Findings/conclusions:** The results suggest this polyculture system may be feasible, and longer duration culture are recommended.

**Keywords:** co-culture, river shrimp, Pacific fat sleeper, shelter, feed deprivation.

**Citation:** Musin, G. E., Badillo-Zapata, D., Vega-Villasante, F., Chong-Carrillo, O., & Palma-Cancino, D. J. (2022). Survival of the prawn *Macrobrachium tenellum* (Smith, 1871) in confinement with the native fish *Dormitator latifrons* (Richardson, 1844). *Agro Productividad*. <https://doi.org/10.32854/agrop.v15i1.2088>

**Editor in Chief:** Dr. Jorge Cadena Iñiguez

**Received:** July 14, 2021.

**Accepted:** December 12, 2021.

**Published on-line:** January, 2022.

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## INTRODUCTION

Polyculture systems are becoming more relevant among producers in global aquaculture. Polyculture requires two or more cultured species in the same physical space at the same time (Stickney, 2013), preferably with different ecological niche (Wang & Lu, 2016). The

importance of polyculture systems in today's aquaculture lies in its capacity to be a valuable option to increase the efficiency and the sustainability of production systems (Dumont *et al.*, 2013), and in improving the system functionality by taking advantage of coexistence and interaction between species (Thomas *et al.*, 2020). Other advantages of implementing a polyculture grow-out are the mitigation of environmental impact of effluents, reduction of nitrogenous waste, and provide food security for rural population (Martínez-Porchas *et al.*, 2010).

One of the main requirements of this production systems is to utilize compatible species in environment, and that these species do not present antagonistic feeding behavior (Wang & Lu, 2016). Although is very common to use two or more fishes of high economic value (Stickney, 2013), several studies report the positive results of polyculture grow-out with prawn of the *Macrobrachium* genus and tropical fishes (García-Pérez *et al.*, 2000; Dos Santos & Valenti, 2002; Tidwell *et al.*, 2010; Cebreros *et al.*, 2013; Henry-Silva *et al.*, 2015).

*Macrobrachium tenellum* is a tropical species of prawn with gastronomic importance and great market value in Mexico, Guatemala and El Salvador, when is commonly referred as river shrimp (Vargas-Ceballos *et al.*, 2020). This species is found in abundance in natural populations mainly near coastal areas; has a high tolerance to temperature, salinity and dissolved oxygen fluctuation and is not an aggressive species (Espinosa-Chaurand *et al.*, 2011). Garduño-Dionate *et al.* (2017), mention that in its natural environment this prawn is over-fished, and commonly caught when individuals have not reach minimum size to secure the ecological renovation of their wild populations. The high adaptability and growing impact in their natural populations, give *M. tenellum* a high opportunity for its aquaculture development (Ponce-Palafox *et al.*, 2006; Espinosa-Chaurand *et al.*, 2011). Recent information about the grow-out of *M. tenellum* suggest is necessary to integrate methods and techniques used in other tropical shrimps to increase the cultivation effort of this resource (Peña-Herejón *et al.*, 2019). In this regard, polyculture systems represent an interesting alternative to increase the production and availability of farmed shrimps in Mexico.

The Pacific fat sleeper (*D. latifrons*), is a native fish with an increasing importance as food resource in many coastal regions of the Pacific in countries like Mexico, Ecuador and Peru (Castro-Rivera *et al.*, 2005; Basto-Rosales *et al.*, 2019). Polyculture viability of *D. latifrons* with other fishes is currently under study, and there's still a potential for the development of sustainable farm systems with other species that could benefit from the synergistic relation with the Pacific fat sleeper.

After the evaluation of the aforementioned information, we decided to test the potential compatibility of *M. tenellum* and *D. latifrons* with the implementation of a co-culture system to evaluate the survival of the prawn under confinement conditions with the fish, considering the presence and absence of food and shelters. The aim is to determine if it would be efficient to consider a polyculture system with both species.

## **MATERIALS AND METHODS**

To evaluate our proposition, we used individuals of *M. tenellum* and *D. latifrons* collected in El Quelele Lagoon located in Nuevo Vallarta, Nayarit, Mexico, and in El Salado estuary

located in Puerto Vallarta, Jalisco, Mexico. The organisms were transported under constant aeration ( $4 \text{ mg O}_2 \text{ L}^{-1}$ ) inside a 400 L water container to the facilities of the Laboratory of Water Quality and Experimental Aquaculture (LACUIC) from the Centro Universitario de la Costa (University of Guadalajara), in Puerto Vallarta, Jalisco, Mexico. Inside the laboratory the fishes underwent an ectoparasite removal treatment in a 200 L container with a concentration of 0.3 mL of Dimilin<sup>®</sup> (diflubenzuron 22%) for 10 minutes. The fish and prawns were kept separate by species in a seven-day quarantine in 500 L water tanks with constant recirculation. Dissolved oxygen was monitored daily using an oximeter (YSI<sup>®</sup> 550 A).

After expiration of the quarantine period, we design a series of three assays using different size organisms from each species. In a first assay (T1) 15 random organisms of each species were arranged in circular tanks with 1,700 L capacity and a dimension of  $2.37 \text{ m}^2$  (density:  $13 \text{ individuals.m}^{-2}$ ), with and without shelters (eight PVC pipes in each tank), using three replicates for each treatment. Before sow, the organisms were measured in size and weight (Table 1). Then, the prawns were stocked first and later the fish. Organisms were fed *ad libitum* during a four-day period, following by a two-day feed deprivation period. To evaluate survival in this assay, organisms of each species were counted after the expiration of each period.

The second assay (T2) consisted in the confinement of three of the larger fish resulting after the first assay with 15 random prawns in 1,700 L tanks and a dimension of  $2.37 \text{ m}^2$  (density:  $8 \text{ individuals.m}^{-2}$ ) with or without shelter (eight PVC pipes in each tank) (Table 1). The fish were randomly located in the three replicates of each treatment. For this assay we proceed with feeding and feed deprivation periods similar to T1, after each period was over the surviving organisms were counted.

The third assay (T3) was realized in 40 L fish tanks, each one with 10 prawns and three fish of shorter size that the previous assays (density:  $104 \text{ individuals.m}^{-2}$ ) (Table 1). As in the previous assays, we tested a treatment with shelter and without shelter (four PVC pipes in each tank) with three replicates. Feeding and feed deprivation periods were the same as the previous assays, and we counted the surviving organisms by species after every period.

All trials lasted six days and the same balanced feed was used in all of them (commercial balanced feed for tilapia “Grow fish Tilapia 2<sup>®</sup>”: protein 35%, moisture 12%, fat 5.6%, crude fiber 5%, ash 8% and ELN 34.5%). During all the assays, we registered the water physicochemical parameters (temperature, dissolved oxygen and pH) on a daily basis.

**Table 1.** Design of the assays: initial average size (mean  $\pm$  SD) and number of individuals of each species per tank (unit).

Species	Assays					
	T1		T2		T3	
	Size (cm)	Ind. Unit <sup>-1</sup>	Size (cm)	Ind. Unit <sup>-1</sup>	Size (cm)	Ind. Unit <sup>-1</sup>
<i>Macrobrachium tenellum</i>	4.95 $\pm$ 0.82	15	4.95 $\pm$ 0.82	15	1.38 $\pm$ 0.35	10
<i>Dormitator latifrons</i>	20.60 $\pm$ 2.93	15	26.39 $\pm$ 1.46	3	9.50 $\pm$ 1.77	3

A statistical evaluation was performed with the Friedman’s test taking average size, presence/absence of feeding and presence/absence of shelter as factors (explanatory variables), and the survival of the prawns as the response variable. The Friedman test was performed using the R-software (R Core Group, USA) with a statistical significance of  $\alpha=0.05$ .

## RESULTS AND DISCUSSION

The results in each assay suggest that the survival rate of the prawns were not affected by the feeding or fed deprivation period, the presence/absence of shelter or the average size of sow ( $p<0.05$ ) (Table 2). The lower survival rate of *M. tenellum* obtained in T3 may be due to depredation from the fish caused by the smaller average size of the prawns (1.38 0.35), a size that is considered in the post-larval range (Jáuregui-Velázquez & Bárcenas-Gutiérrez, 2017). In this regard, New & Valenti (2017) indicate small size in prawn makes them susceptible to be eating by fishes in aquaculture systems. The prawns that not survive during T1 and T2 were found dead, dismissing the idea that they were preyed upon by fish in those assays. A better survival rate was observed in T1, suggesting that the same amount of prawns as fish not only has better biological performance but also can improve the economic revenue provided by the production system.

During our assays, many interactions between prawns and fish were observed, which may have an impact on the survival rate. In *M. tenellum* of large size is common to find some social hierarchies when some alpha males exercise dominion over the rest of the population, negatively affecting the growth and survival of said population (Vega-Villansante *et al.*, 2011). This behavior observed in several species of the *Macrobrachium* genus (Karplus & Sagi, 2010), can be countered with the use of shelter in growing areas (De Los Santos-Romero *et al.*, 2018). In our results, the use of shelter had no significant effect on the survival of the prawns, however, it’s important to consider the use of shelter to prevent events of mortality or growth impairment that could affect the production system.

Another interaction observed in decapod populations is the cannibalism of the soft organisms that have just been molted by the harder ones. Cannibalism is mostly observed during molting and post-molting cycles in post-larvae and/or juvenile stages (Tidwell *et al.*, 2010). The use of different types of natural or artificial shelters has proven to be an

**Table 2.** Survival rate of *Macrobrachium tenellum* obtained after each period (feeding and fed deprivation) in assays with *Dormitator latifrons* (mean percentage  $\pm$  SD).

	Experimental unit	Fed <i>ad libitum</i>	Fed deprivation
T1	With shelter	97.78 $\pm$ 3.85	97.78 $\pm$ 3.85
	Without shelter	100 $\pm$ 0.00	100 $\pm$ 0.00
T2	With shelter	91.11 $\pm$ 10.18	92.44 $\pm$ 0.84
	Without shelter	86.66 $\pm$ 11.55	86.15 $\pm$ 13.64
T3	With shelter	56.67 $\pm$ 45.09	100 $\pm$ 0.00
	Without shelter	56.67 $\pm$ 41.63	100 $\pm$ 0.00

The survival rate of fed deprivation period was calculated using only the survival individuals counted after the previous period. Friedman’s test did not show statistical differences.

effective countermeasure for cannibalistic or other antagonist behaviors during shrimp pre-juvenile production (Karplus & Sagi, 2010). In T3 we observed a significantly lesser survival rate in the prawns; as mentioned before, this was probably caused by depredation from the fish, but it's important to not discard cannibalism. Even after not finding statistical differences in the survival for the use of shelter, the state of the art about this topic suggest it's extremely important to provide shelter when shrimps are about the average size of T3 (Ponce-Palafox *et al.*, 2006; Espinosa-Chaurand *et al.*, 2011; Vargas-Ceballos *et al.*, 2020).

This study is the first report of polyculture of *M. tenellum* with the native fish *D. latifrons*, and assays with other fishes are scarce. Vega-Villasante *et al.* (2011), tested the survival of *M. tenellum* juvenile in polyculture with different species and strains of tilapia, obtaining good survival rate for the juvenile in systems with Nile tilapia *Oreochromis niloticus* and Mozambique tilapia *O. mossambicus* (no evidence of predation by the fish), similar to our results in assays using juvenile prawns (T1, T2). However, when using more actives and growth-efficient tilapias like blue tilapia *O. aureus* and Thai-Chitralada *O. niloticus* strain (Curzon *et al.*, 2019), the mortality of *M. tenellum* was almost total (Vega-Villasante *et al.*, 2011); in this regard, observations during our assays suggest *D. latifrons* does not show antagonistic behavior when the prawns are of juvenile size (Table 2). The omnivorous nature of *D. latifrons*, and low antagonistic behavior observed toward juvenile shrimps, suggest it's a great fish option for the development of co-culture, biculture or polyculture systems with *M. tenellum*.

Other species of *Macrobrachium* are most commonly used in polyculture systems with fishes like tilapia or carp (New & Valenti, 2017), comparing the survival obtained during our research with the performance of *M. rosenbergii* in different polyculture systems, we found mixed results. Dos Santos & Valenti (2002) reported an average survival rate of 90% of *M. rosenbergii* cultivated with *O. niloticus* at different densities, and the prawn did not negatively affect the fish growth; when comparing that survival rate with the one observed during this study for T1, T2 and T3, the performance for *M. tenellum* was very similar. The similarities between survival rate of both systems may suggest that the interaction between the species can contribute to more sustainable production and more environmental friendly, also supported by the fact that in our study the survival was not affected by the fed deprivation period, suggesting that the prawn fed upon the not consumed fed and the feces of the fish. The survival of *M. tenellum* juveniles obtained in this study was similar to the survival of *M. rosenbergii* reported by Tidwell *et al.* (2010), who obtained between 87.5-96.3% with tilapia cultivated in floating cages; and higher to the survival reported by García-Pérez *et al.* (2000), who obtained 36-43% of survival for *M. rosenbergii* with tilapia, they also mentioned that high mortality of the shrimp may be related to the cannibalistic behavior observed during the grow-out and to predation by birds unrelated to the cultivation.

The survival of *M. tenellum* in our assays was more than adequate comparing with other two species of prawns. It was higher than *M. amazonicum* in a multi-trophic culture with tilapia, when the survival of the prawns fluctuated between 61.5-77.3%, without affecting the tilapia production (Henry-Silva *et al.*, 2015). Meanwhile, compared with *M. americanum* in ponds with tilapia, the prawn showed survival rate very similar to the obtained in our experiment, with low performance of post-larvae (43%), and better for

juveniles with 86% (Cebberos *et al.*, 2013). It's important to mention that our assays lasted less than the experiments used for comparison, however, only during our assays it was used a fed deprivation period.

Taking into account that in semi-intensive ponds, the survival of prawns and shrimps varies between 50-80%, after six to eight months, and that during storage and harvest of shrimps a minimum of 50% of survival is required to become feasible (Valenti *et al.*, 2010); the results obtained in our preliminary assays are acceptable and within the expected survival range. It's pertinent to realize trials or assays with both species, at higher densities, and with longer duration.

## CONCLUSIONS

All these preliminary assays are the first report of survival evaluation of *M. tenellum* in confinement conditions with *D. latifrons*. The results obtained suggest a co-culture or polyculture system with both native species can be feasible using juveniles of *M. tenellum* and fish larger than  $9.50 \pm 1.77$  cm because predation risk is significantly lower. We do not found statistical differences between providing shelter or not, but to prevent antagonistic behavior between the species, or alpha male effect and interspecies cannibalism in the prawns during longer confinement, it is recommended the use of shelters in the tanks. Continuing research about this polyculture system will have an important impact on fisheries and aquaculture in central Mexican Pacific region, preventing exotic species introduction like tilapia may diminish the wild populations of both species and providing food security for the region with a more diverse protein source availability.

## ACKNOWLEDGEMENTS

Gabriela E. Musin thanks the Government of Mexico, through the Ministry of Foreign Relations, for the scholarship awarded. Daniel Badillo-Zapata want to thanks CONACyT and the Cátedras project of CONACyT for the support provided for carrying out this study. David J. Palma-Cancino thanks the CONACyT for the grant No. 769329 provided for his postdoctoral research.

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