

Some Aspects of Feeding and Nutrition of Native *Farfantepenaeus duorarum*

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Abstract

F. duorarum native from the area of Yucatán were studied to know the requirement in nutrients and energy under laboratory conditions. At postlarval (Pl's) stages dietary protein level had an effect on substrate metabolism measured through the variations of O:N ratio (5-15). Pl's responded to dietary protein levels and heat increment of feeding (HiE) ranged from 0.3-0.4kJ/animal/day. Both practical and purified diets were tested. Purified diets formulated in a range of 40-65% CP content showed a better performance at a high level (60%) based on casein. Lipids were incorporated at a high level (>15%) without affecting the weight gain that contrasted with what was used to observe at juvenile stages. At juveniles stages protein requirement was estimated at 30%CP. However, recent data to explain feeding habits in natural environment indicated that a change in enzymatic activities and the ratio amylase/trypsin in a range of 2 to 10 according to seasons. Stomach contents confirmed the trend for a carnivorous regime. Moreover, wild juveniles fed in the laboratory with practical diets showed an improved assimilation when fed a commercial diet as compared with this same diet supplemented with *Artemia* biomass. Domesticated juveniles from F² generation got a better weight gain than wild shrimp, when fed either marine protein diet (MAD) or vegetal protein diet (VPD). From overall observations, even though *F. duorarum* was characterized as a carnivorous species, domestication process could improve its utilization of plant protein and carbohydrates to spare fish meal.

Key words: *P. duorarum*; nutrition; ecology. nutrigenomics; physiology.

Introduction

Actually shrimp farms development is based on largely domesticated and usually foreign species for many countries. To get sustainable approach is necessary in the future to succeed domestication programs for native species. For Yucatán Peninsula, a research program is focusing on the pink shrimp of Gulf of Mexico, *Farfantepenaeus duorarum*. Multiple aspects are considered such as study of species in his environment, reproduction in captivity, nutrient requirements (Gaxiola *et al.* , 1998), several formulations of compounded feeds, preliminary aspects of nutrigenomics and different intensive growth out systems including the use particulate biomass (floc). One of the reasons to reactivate the domestication program of the pink shrimp I related to the norm constrains put by the European market regulating strongly imports according to the ISO 2000 concept. This can be very attractive opportunity for regional investment for both commercial or backyard hatcheries. The social and economic impact will be evaluated in the near future, for the coastal area

1. Feeding status of wild shrimp placed under laboratory conditions.

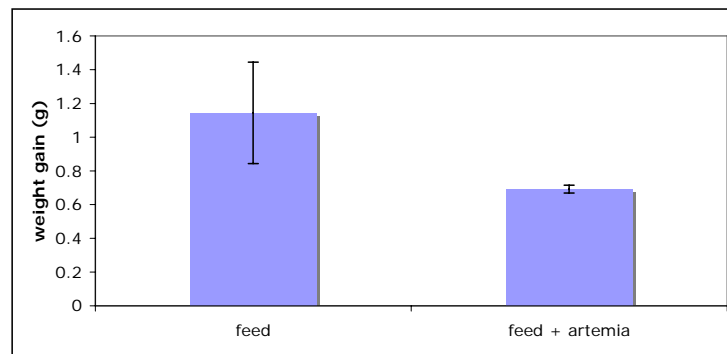


Figure 1. Weight gain reached during 4 weeks of wild juveniles of *Farfantepenaeus duorarum* fed commercial feed (35% of protein) and feed+ Artemia biomass (UMDI-Sisal data not published).

By other side, a comparative study was performed using wild (WJ) and cultivated (F2, CJ) juveniles of *F. duorarum* fed isoproteic and isoenergetic marine animal protein diet (MAD) or vegetal protein diet (VPD). Survival was not affected either the origin of the shrimp or protein quality ($p > 0.05$, Table 1).

Table1. Survival (%) during 45 days of wild (WJ) and cultivated juveniles (CJ) of *Farfantepenaeus duorarum* fed marine animal diet (MAD) and vegetal protein diet (VPD).

Treatment	Survival (%)
CJ-VPD.	80 ^a ±7.1
CJ-MAD.	86 ^a ±11.4
WJ-VPD	72.5 ^a ±17.1
WJ-MAD.	80 ^a ±7.1

However weight gain (g/week) was higher in cultivated juveniles fed MAD diet, and the lowest value was observed in wild juveniles fed VPD ($p < 0.05$, Fig. 2)

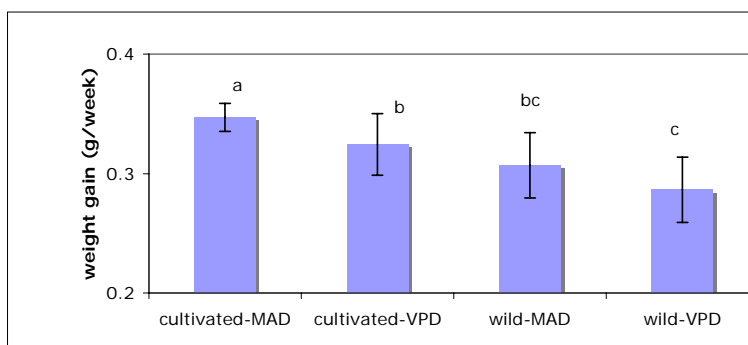


Figure 2. Weight gain (g/week) of wild and cultivated juveniles fed marine animal protein diet (MAD) and vegetal protein diet. Letters indicate the differences at level 0.05.

2. Nutritional requirements (Gaxiola *et al.*, 1993; 1998; Rosas *et al.*, 1995) with information on PL's and juveniles.

Apparent caloric increment and O:N ratio of postlarval *Penaeus setiferus*, *P. duorarum*, *P. schmitti*, and *P. notialis* fed on different dietary protein levels. O:N ratio were measured in postlarvae (PL 35-40) of *Penaeus setiferus*, *P. duorarum*, *P. schmitti* and *P. notialis* with respect to the purified diets with different protein levels (Rosas *et al.*, 1993). Oxygen consumption and ammonia excretion of *Penaeus setiferus*, *P. schmitti*, *P. duorarum* and *P. notialis* postlarvae fed purified test diets: Effect of protein level on substrate metabolism was performed by Rosas, et al (1995) in *Penaeus setiferus*, *P. schmitti*, *P. duorarum* and *P. notialis* postlarvae PL 35-40 (35-40

days after metamorphosis) fed purified diets with different levels of proteins. Evaluation of protein requirement of postlarvae *Penaeus setiferus* and *P. duorarum* was done with the use of purified diets. The requirement of protein by postlarvae of *Penaeus setiferus* and *P. duorarum* was evaluated through growth and survival in two experiments using purified isocaloric diets with protein contents of 40, 50, 60 and 65% (Gaxiola, 1993). Although postlarvae can cope with high dietary lipids from fish oil and 1% lecithin maintained constant, performances are not clearly affected; by and large lower energy levels would fit better than higher ones. High lipid levels (above 18%) would saturate the digestive capacity (fatty acids absorbability level), same as for larvae. But at the same time, such high lipid content food exists with *Artemia nauplii*. Therefore it fits for larvae and PL's with a protein/lipid ratio of 52/20 dry wt (or 18/4 live wt). Older penaeid larvae or PL's stages can develop with high dietary lipid levels and were studied from a species point of view (Gaxiola, 1994). PL's were fed experimental casein-based diets in a wide range of lipids from 8-30%. This range of variation led to test, from an energy view point, two levels: 13kJ/g and 17kJ/g. The lower range of dietary energy (calculated with coefficients 4:9:4) provided optimal growth rates at 19 and 45 mg protein/kJ for *P.setiferus* and *F.duorarum* (Fig.4), respectively.

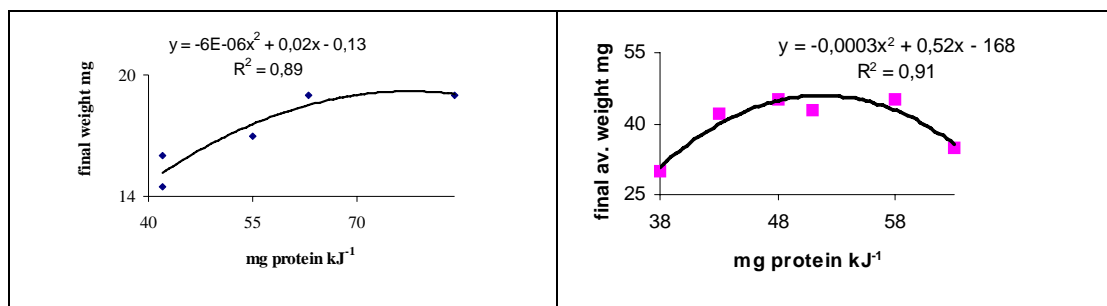


Fig.4. Comparative aspect of protein energy ratio in postlarvae fed practical diets: left:P/E ratio polynomial regression for *L.setiferus* PL's at energy levels (13 and 17kJ/g). right: P/E ratio polynomial regression for *P.duorarum* PL's fed high lipid diets.

In contrast and from a comparative view point *L. setiferus* and *F. duorarum* PL's appeared to tolerate energy dense diet and optimal growth was achieved among different P/E values (Gaxiola, 1994). PL's preserve their ability to tolerate high dietary lipids without apparent saturation of the digestive tract. Colvin and Brand (1977) tested *L.vannamei* PL's at a constant energy level and several protein levels to sort out a value of 40% at an energy level (DE recalculated) of 13 kJ/g,

in line with previous levels found with other penaeid species. Is the lipid level given for PL's accepted by juveniles? All previous data tended to show that there was a limitation in lipid utilization by juveniles even when fed on quality fish oil such as squid oil. It looked like shrimp was covering its requirement in essential fatty acids (EPA and DHA) and oils high in n-3 PUFA's resulted in improved growth rates of *P.duorarum* (Sick and Andrews, 1973). Then excess fatty acids combined in triglyceride forms coming from different plant or marine sources did not contribute to a sparing effect of dietary protein for example. During *in vivo* digestibility studies it was found that an excess of dietary lipid produced an accumulation in feces rendering the strands very fragile and not easy to collect. Obviously the result in ADC lipid was in this case quite low (about <60%).

Seasonal and nutritional effects on the fatty acids of three species of shrimp, *L setiferus*, *F. aztecus* and *F.duorarum*, species of shrimp from the Gulf of Mexico were analyzed periodically for one year. The fatty acid patterns of species of shrimp collected varied and the presence of arachidonic acid was found noticeable in *P.setiferus* (Bottino *et al.* , 1980).

Growth and yield of pink shrimp (*F. duorarum* Burkenroad) in a feeding experiment in ponds (Caillouet, 1974). A feeding experiment was conducted with pink shrimp (*P.duorarum*) in ponds at Turkey Point in southeast Florida during May-October 1972.

Table 2. Growth and yield of pink shrimp (*Penaeus duorarum* Burkenroad) in a feeding experiment in ponds (Caillouet *et al.*, 1974).

		day 92			day 156			
density	feed	feed level	av wt g	survival	kg/ha yield	av wt g	survival	kg/ha yield
7.5/m2	w.bran	19	6	75-94	402			
7.5/m2	catfish feed	19	8			12.5	50	472
15/m2	w.bran	12		75-94				
15/m2	catfish feed	19		75-94	555			

Postlarval shrimp were stocked at two densities (75,000 and 150,000 per ha), and two feeds (wheat bran and catfish feed).

In 36 concrete tanks, growth and yield of pink shrimp postlarvae (*F duorarum*) in feeding experiments during a 63-day with pink shrimp, *F.duorarum*, each 2m² gave the results presented

in table 1; feeds tested included a commercial catfish feed, wheat bran, wheat straw, hay and bagasse; catfish feed gave the best average yield at 7.5 per m² (Caillouet *et al.*, 1976).

Chemoreception and feeding behavior in the pigfish, *Orthopristis chrysopterus*: characterization and identification of stimulatory substances in a shrimp i.e. substances in shrimp (*F. duorarum*) extract that stimulate feeding behavior in *O. chrysopterus*, were characterized and identified. The stimulatory agents had properties consistent with amino acid-like substances as indicated by molecular weights (Carr, 1976).

3. Conditions of feeding for breeders, spawning and natural mating.

Hudinaga (1942) opened the way of the modern aquiculture with the reproduction in captivity of *P. japonicus* by taking animals of the natural environment. However the dependence of wild parents could last only a time. The reproduction of shrimps was one of the first subjects of investigation of the experimenters when the aquiculture taken his rise with upright of the seventies (Laubier-Bonichon, 1978; Primavera, *et al.*, 1979; Aquacop, 1975). The facility to obtain the reproduction in captivity will quickly become one of the first selection criteria of the species candidates for breeding. Starting from a natural food (mussels,...) the very first results were obtained while playing with the abiotic factors such as temperature, photoperiod (Laubier-Bonichon, 1978). Then, in fact the hormonal factors took the top in the inventory control of reproducers; one rediscovered “the Panouse effect” (1943). This technique opened immense prospects for the aquiculture (Aquacop, 1975). This maintenance of reproducers in captivity will produce various constraints among which the nutrition (Cuzon *et al.*, 1995; Wouters *et al.*, 1999). One will realize importance of the lipids and of two vitamins in particular, E and C. Meanwhile, the development of known food as for maturation will meet various fortunes. And the difficulty in testing on future reproducers will limit in a certain manner the research effort. To do without “fresh food” will remain an objective during years. Then, according to the availabilities of earthen ponds, one will take the option of breeding to low density (2/m²) in order to make benefit the animals from the natural productivity. The improvement of the formula of known food helped “enlargement”, which will involve also better performances of the reproducers; the history of the animals to some extent became data to take into account. In spite of the relative stability of the environmental conditions in tropical medium, one realized

difference in performances of reproduction at the same time of males and females. And the concept of warm season (29-30°C) and cold season (25°C) took all its importance. In the same way, the water quality for breeding seemed being a determining factor.

At laboratory level, *P.duorarum* could be reproduced in captivity at Celestun and it ease the procedure because the females mature without ablation and mating occurred in breeder tanks in field station (Merino, 2004; com.pers.). In UMDI-Sisal maturation facility, a comparative research was done between wild and cultivated (F2) specimens. From both origin, the maturation and natural copulation was effective to obtain fertilized eggs and in both the hatching percentages were very similar. But in cultivated females the maturation was reached between 19.6 and 20.4 g whereas the wild ones presented maturation at 30.86 g (Table 3)

Table3. Spawns/female, rematuration, eggs/spawn, fertilized eggs number, fertilization rate, living nauplii and eclosion rate of wild and F₂ of *Farfantepenaeus duorarum* . (Emerenciano data no published UMDI-Sisal)

	n.	Spawn	Rematuration	Female	eggs/	Fertilized	Fertilization	n°	Hatching
	spawn	/female	(mean)	weight	spawn	eggs/female	rate.	nauplii	rate
				(g)	(thousand)	(thousand).			
Wild	63	3.15	3	30.86	70.5	55.2	70.2	47.9	69.5
F2	38.0	2.2	1.6	19.6	33.1	26.2	73.3	25.7	67.0
F2	29.0	1.7	1.5	20.4	25.9	25.9	74.0	23.0	60.2

After years of trials and errors, one put the question of the relevance of breeding of future parents in conditions of “bacterial floc” or floc mixed bacteria+micro-algae. Within sight of the performances of the animals, extrapolation in the conditions of maturation proved to be useful. This work result in showing an increase in the performances of reproduction of animals maintained in conditions of captivity since years and placed in conditions of floc compared to those than come from the traditional method of breeding out of earthen ponds. By doing this, the management of breeders was simplified with in particular the possibility of holding shrimps in conditions of controlled temperature, in a way easier than out of ponds. Would nutritive contribution related to the floc bring a significant change at the biochemical level (Racotta *et al.* , 2003) and at the physiological level with an extension of the lifespan of the females and thus of their prolonged use in maturation area? in the same way eyestalk ablation will still be essential in the long term? The eyestalk ablation involved a premature ageing of the animals and could be replaced essential under new conditions of breeding?. This report was made at the same time on

L. stylirostris and *F. paulensis* in conditions of floc. Will it be possible to identify a new maturation food? all these questions at the same time for zootechnical procedure, biochemical and physiological aspects as well as genetic should be approached through experiments.

Conclusion

- 1.- In its natural environment, *F. duorarum* juveniles can find many carbohydrate sources and a biochemical adaptation in digestive enzymes according to seasons.
- 2.- The domestication of *F. duorarum* begins to improve the weight gain with good perspective to reach more than 10% gain after few generations.
- 3.- From variations in lipid and cbh content, Pl's were studied for their requirements in protein and energy with consideration of P/E ratio.
- 4.- Whole life cycle can be controlled in captivity for such species that can mate without need for artificial insemination and spawned and produced quality eggs. Feeding breeders with a combination of fresh food and compounded feed was found adequate.
- 5.- Next stage for *F. duorarum* culture would take into account (i) nutrigenomics (differential expression) and set-up of a DNA library for hepatopancreas genes (ii) the potential for culture in "floc" conditions will be worth to be evaluated.
- 6.- From a practical viewpoint, extension for *F. duorarum* in Yucatan area has economic constraints. But structures (farms and hatcheries) should be put forward. The heart of the operation is the hatchery (i) a pilot-hatchery at UNAM/UMDI-Sisal then (ii) a production hatchery that will give the starting point to an aquaculture activity. Which activity? -family level-fishermen communities? -large farm let us say 3-400t per year? Would the idea be to privilege a large unit (private capital? or financing from the district of Yucatan?). It would function on a statute of company but it would have the duty of "swarming" that is to say that in addition to its production it would be held "to distribute "postlarvae to the surrounding villages and besides it would have a margin of safety as regards to food purchased from feed companies or programmed in connection in order to make it possible to the villagers to take food at the request without too much financial expenses, little storage, a good management. There one would hold synergy between production for marketing by the normal networks (standard large distribution) and development of a small side activity for the fishermen of the neighboring villages such as Celestun or Progreso. Moreover, always for native shrimp and from the point of view of

restocking it is necessary to identify the mangroves areas likely to accommodate a release operation of postlarvae or juveniles and to set up a team for the follow-up of the impact of this action, with an active contribution of the local fishermen whose benefit from the operation would return to them as far as the action proves to be feasible on the long run.

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