Chapter 2

Development of Freshwater Native Species with Aquacultural Potential

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Additional information is available at the end of the chapter

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1. Introduction

Aquaculture is an activity practiced by Chinese people since 2800 B.C. The first culture species were the carp (*Cyprinus carpio*) and mullet (*Mugil cephalus*), the first documented knowledge about fish culture in captivity belong to the carp. This activity has been supporting human demands for fish products for centuries and now is an important worldwide industry. Over the years this practice has become more technical with the objective to make the work easily but mainly in order to increase production. Nowadays this activity has grown to an entire industry that handles both supplements as the product itself. Global production from aquaculture now supplies one third of seafood consumed worldwide. With this massive increase in world production the current aquaculture industry is one of the fastest growing sectors in food production [1]. However, this rapid growth in the aquaculture industry has generated ecological damage due to a huge extractive use of water, land, and feeds. Besides, is important to consider that these requirements are associated to another impacts such as; polluting, salinization of soils, nutrient-loading, clearing of natural habitat, overexploit of ground water reserves, introduction and transmission of diseases [2]. At this respect Bailey [3] establish a new term "blue revolution", which describes the expansion of fish-farming in tropical regions, according to this idea aquaculture must provide huge quantities of fish and help to solving problems of world food security and alleviating poverty. However, production increase in aquaculture demands feeds, energy for the cultured species and almost always is obtained through catch, so the fastest growing sectors in food production threatens its ability to continue to provide increasing yields in a sustainable manner, and concerns with the resulting from fish-farming have led to calls for the "greening of the blue revolution" [4].

The situation in México is not an exception; the expansion of aquaculture has been accompanied by degradation of the natural environment, especially on marine aquaculture [5]. As it happens in the world directly impacts of fisheries and aquaculture are:

- Introduction of nonnative fish species:
- Introduction of exogenous parasites:
- Nutrient pollution:
- Habitat modification:
- Overcollection of wild seed stock:
- Changes of food webs
- Increase of interspecific competition:

It is clear that current food productions techniques in aquaculture are good just under financial point of view but always leave aside the environment aspects. The relationship between aquaculture and environment is complex specifically the biodiversity topic. Many examples of positive and negative impacts have been documented, however until now there is no solution which allows the development of a relationship between food production and the environment. This solution must be adopting a new paradigm based in ecological concepts of extreme resource efficiency and the closing of nutrient and waste cycles, resource-use optimization [6]. As can be seen, this is not an easy task since it requires the creation of multidisciplinary teams which can see the problem holistically and try to give a solution that benefits all parties involved in the process. The efforts and the perception of the environment are different between countries, but ultimately the problem to be addressed holistically. However, studies on fish typically focus on species that currently have commercial value, causing species that lack such market value to be ignored. This is the case of several freshwater native species, which can be founded in central and South America. Some attempts to cultivate native species have occurred mainly in areas or rural communities, where in addition to enhance the conservation of species protein contributes to the diet of the community [7]. One of the most interesting case studies in Mexico is growing "white fish" (*Chirostoma estor*) with the aim repopulate some areas where the introduction of their populations has been declined [8]. Most documented is that of the native Central American cichlid (*Cichlasoma urophthalmus*), of which there have been many studies to support its culture [9]. In southern region some attempts to grow some silversides in Argentina (*Odontestes Basilichthys*), some Characidae family members have been grown in Brazil and more recently three species of carnivorous cichlids aquarium purposes. In Peru it has favored the cultivation of called piracucu (*Arapaima gigas*), one of the largest fish of fresh water. Possibly the Cichlidae family members are those that show the greatest potential for cultivation [10, 11].

The main purpose of this chapter is to show the experience of three studies with native species; one refers to a small native species located in the state of Querétaro and with a great ecological importance, *Girardinichthys multiradiatus* [12]. The study of this fish focused on the description of its habitat throughout a hydrologic cycle in which ecophysiological responses were determined in order to stablish guidelines for its management and to preserve its population. In this work population structure and dynamics were getting and trophic and ecophysiological responses to fluctuations in environmental factors were also identified in order to have the possibility of laboratory reproduction and growth. On the other hand, native mojarra *Herinchthys cyanogutattus* founded on the basin Pánuco river. In this case the purpose was to evaluate its useful in fishery and later in the aquaculture. The work consisted of two stages: First, the characterization of their environment in order to locate stable populations of the mojarra and to characterize ecologically its habitat. Second, the mojarra was moved to the laboratory to try different forms of acclimatization for its future use giving them tried food. Once acclimated, the stock was use to carried out density studies of individuals for culture (capacity of load), as well as of ideal thermal for its production. Finally, *Procambarus digueti* which faces severe ecological problems (over fishing, no control of heights neither of sexes, there is not articulated extraction methods neither fishing seasons and restrains), since they are captured as food and as curative remedies from pre-Hispanic eras. To this situation the strong environmental pressure is added by the disturbance of their habitat, what has carried a decrease in numerical abundance. The objective of this work was determined the optimum cultivation conditions with respect to the load capacity and diet in the growth of *P. digueti* in intensive production systems. The controlled production of this specie will reduce the fishing pressure and it will be able to serve to repopulate the sites where may have been decline the natural population.

To successfully achieve the cultivation of a native species, compared to the technological advantages offered by more exotic trading requires knowledge of the biology, ecology and aquaculture potential (ability to live at high densities, accept food encapsulation, and withstand high environmental variations) of each species. If aquaculture potential studies are performed with ecophysiological and bioenergetics approach may be developed predictive models of how to develop a population under different environmental factors, and even develop experimentally testable hypotheses [13].

2. The experience with Girardinichthys multiradiatus

Studies on the biological aspects of fish typically focus on species that currently have commercial value, causing species that lack such market value to be ignored. This is the case of several freshwater fish, specifically of several members of the Goodeidae family. This is a diversified and small family of cyprinodontoid fish, confined to the central plateau of Mexico where its dispersion center lies in the well-isolated Lerma basin. Four species of the Godeidae family have been reported in Querétaro: three species are distributed widely in the Lerma basin (*Goodea atripinis, Xenotoca variata, Goodea gracilis*), and one species (*Girardinichthys multiradiatus*) can only be found in one body of water in the municipality of Amealco [14]. Scientific knowledge about it focuses on sexual dimorphism, peculiar courtship rituals, and viviparity [15], taxonomic aspects [16, 17], ethology [18], biology [19], and trophic ecology [20].

2.1. Environmental conditions

G. multiradiatus was founded on San Martín Dam, located at 60 km south of Queretaro city, near to Amealco municipality (100° 09′ 43′′ W; 20° 15′ 02′′ N), at 2600 meters above sea level. The climate is subhumid with summer rains (Cw1) with an average temperature of 15.1°C, the months of May and June are those with the highest temperatures. The average annual rainfall is 659.5 mm, occurring mainly during the summer [21]. The main contribution to the dam water is from rain. Sampling was made over a full hydrological cycle (one year, beginning in February) in which the *G. multiradiatus* population was monitored once every two months, at the same time physical factors were measure (T°, pH, dissolved O_2, turbidity, depth). The physicochemical parameters of water showed stable behavior during the studied hydrological cycle (pH = 7 to 9; dissolved oxygen = 6.5 to 7 ppm). On the other hand, the temperature showed significant variation, with the highest temperatures (20-25°C) recorded between April and August, with the lowest (10-18°C) recorded between October to February. Also, due to seasonal differences in water usage, the water level of the dam was low from April to August and high from October to March (Fig. 1).

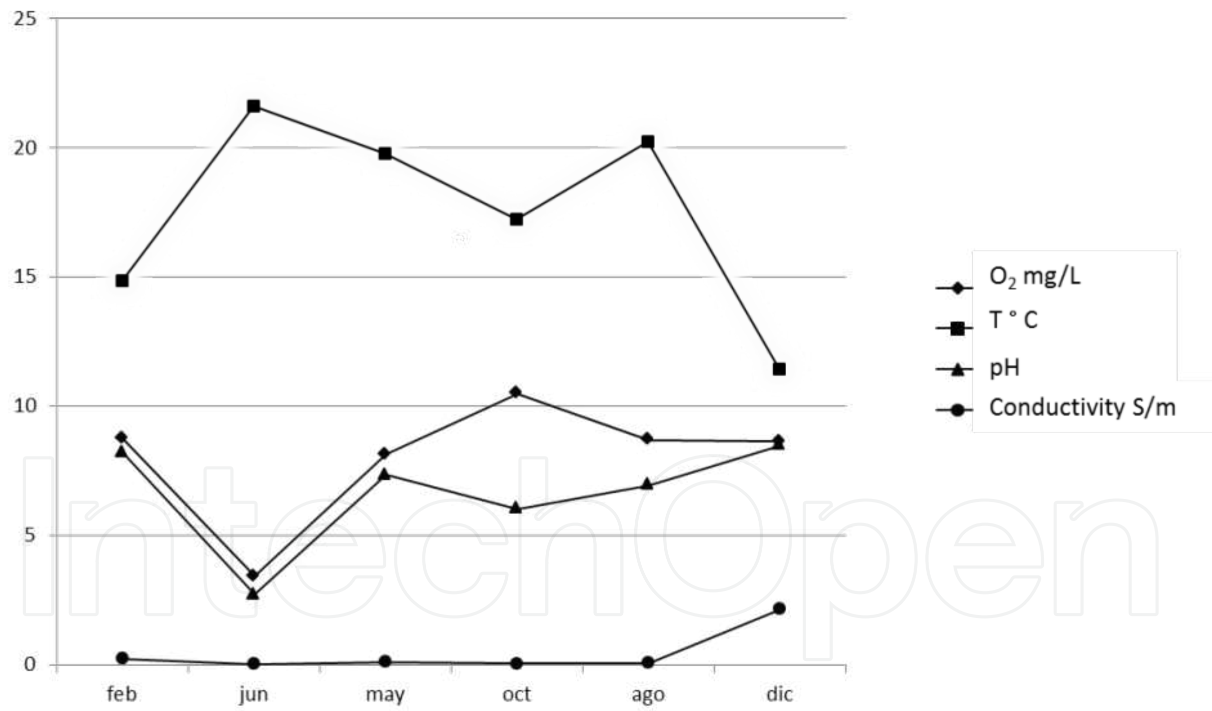

Figure 1. Environmental parameters during a hydrological cycle in San Martín Dam.

2.2. Population ecology

According to the Cassie method, the population of *G. multiradiatus* consists of 12 classes, ranging from 8 to 48 mm standard length. Figure 2 shows the general structure of the mexcalpique population of San Martín. The numbers in parentheses indicate the percentage of each size class of the total population obtained through a year. Two of these size classes were found only in laboratory studies due to their small sizes; these sizes were smaller than what the nets in situ could catch.

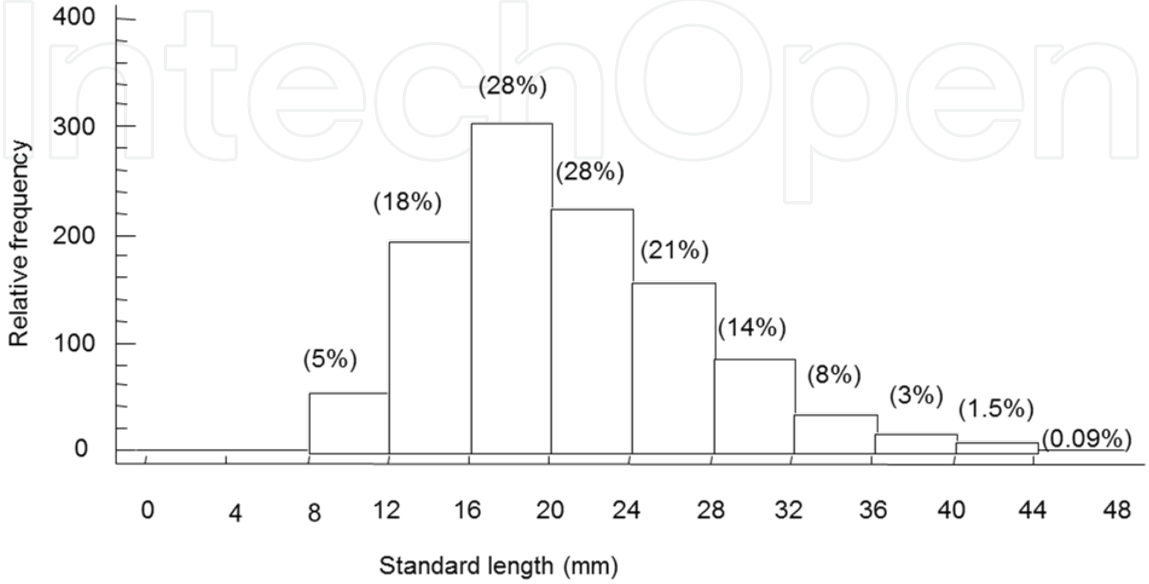

Figure 2. General structure of the population of San Martín mexcalpique. The numbers in parentheses indicate the percentage of each size class of the total population obtained through a year.

Figure 3 shows the bimonthly structure of the population of *G. multiradiatus* in San Martín and the seasonal pattern of population growth, demonstrated in Von Bertalanffy equation with $L\infty = 47$; $K= 0.8870$ and, $t0 = -0.2103$. The variations throughout the year are present in both, in the structure of the population and its growth rate, with the shorter pattern cohorts having a higher growth rate and no increase in length during the period of February to June.

2.3. Feeding habits

To assess the daily feeding activity of the *G. multiraditus* in San Martín Dam samples were collected with spoon nets every four hours during a period of 24 hours (10:00, 14:00, 18:00, 22:00, 02:00 and, 06:00 hours). These catches allowed determining the feeding ecology of the species (feeding time, type of diet at different times of day, food components). The relative density in activity was measured using the catch per unit effort method (CPUE) based on the number of individuals caught by dragging. The fish were fixed in 70% alcohol and then transported to the laboratory (Nielsen et al., 1983). From 1022 stomachs analyzed, (1022), 18 food components were identified. The most abundant component found were insects (47%), especially the Diptera order, followed by detritus (24.0%) and Cladocera (17.5%), with the remaining components accounting for 10.7%. Unusual food components (less than 10% of the total), were only found at a specific times of the hydrological cycle, Table 1. The benthic review showed 20 components and trophic index was calculated indicating that *G. multiradiatus* is a

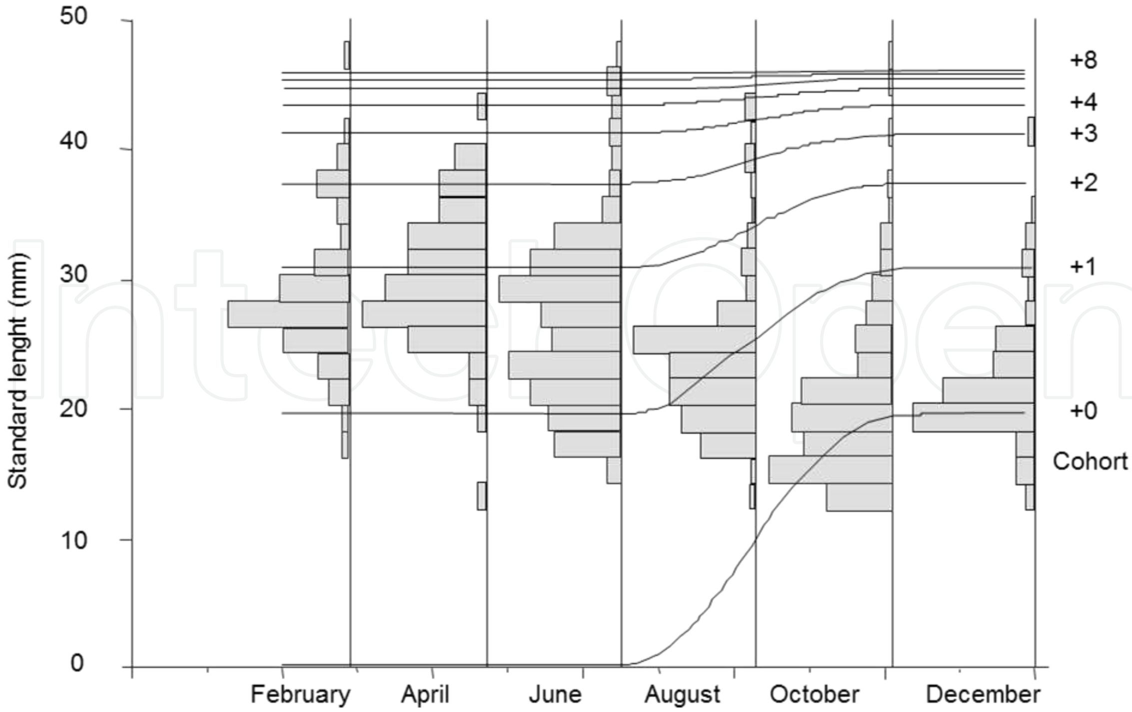

Figure 3. Bimonthly structure of the population of G. multiradiatus in San Martin and the curves of growth with the von Bertalanffy model for highly seasonal cycles. Upon reaching the asymptotic curve determines the final class of each age cohort.

polytrophic specie ($H \neq 0$). The maximum numbers of categories found in their stomachs were eight while minimum was two. Circadian sampling showed that this specie is polytrophic with two daily feeding periods (5:00 to 8:00 and 14:00 to 18:00 hours).

2.4. Bioenergetic

To quantify the aerobic metabolism and nitrogen excretion, animals were placed in a semi closed system with (0.5L) respirometric chambers, using a method which assumes that the reduction of oxygen and the increase of nitrogen in the chamber depend on the weight of the animal, the volume of water, the period of time in which no water circulated in the chamber and the ambient temperature [22]. After each cycle, sample was oven-dried in an electric oven between 70-80°C until the samples had constant weight. From each composite sample 2 g were measured and taken as analytical sample; the samples were digested with concentrated nitric acid. The determination of the percentage proximate composition was chemically analyzed according to the method of analysis described by the Association of Official Analytical Chemist [23]. While other 2 g sample tissue were combusted in a Parr bomb calorimeter to obtain oxycalorific measurements. The flow of energy that was used to determine the energy efficiency and assimilation is show in the next equation:

$C = P + G + ER + EU + F$

Where; C is the total energy content of food consumed, P and G are the energy equivalents of somatic and gonadal growth respectively, ER is the energy utilized in respiration, EU is the

Category	Youth N = 654		Males N = 195		Females N = 173	
	n	%	n	%	n	%
Detritus	230	16.08	141	37.03	127	38.49
Diptera	517	55.31	146	34.32	142	34.41
Cladocera	231	21.5	51	13.73	38	13.73
Copepoda	53	3.78	25	2.26	31	2.26
Animal remains	41	1.27	29	2.56	47	2.56
Amphipoda	20	0.67	27	3.1	34	3.01
Hemiptera	16	0.52	27	2.96	38	2.96
Odonata	13	0.38	21	3.21	28	3.21
Himenoptera	1	0.06	4	0.11	12	0.66
Coleoptera	0	0	2	0.04	6	0.6
Crustacea	1	0.004	4	0.41	4	0.14
Ephemeroptera	3	0.06	0	0	5	0.38
Gasteropoda	3	0.05	1	0.02	6	0.17
Plecoptera	3	0.03	2	0.11	0	0
Thrichoptera	0	0	1	0.1	0	0
Homoptera	0	0	1	0.05	0	0

Table 1. Occurrence of food components (N = number sampled, n = number of organisms that have the category, % occurrence rate) by sex.

energy lost as nitrogenous and other waste compounds excreted in the urine, and F is the unabsorbed energy voided with the faeces (Bolduc et al., 2002; Bradshaw, 2003). All variables expressed in calories per gram of dry weight (cal/g).The ratio used to transform measured aerobic metabolism into calories was the standard oxycaloric coefficient for fish which mainly excrete $N\text{-}NH_4$ (Qox = 3.20 cal mg-1 O_2). Nitrogen excretion was estimated using literary references, taking into consideration the type of fish, size, feeding habits, and physiological status [24].

Physiological experiments showed higher energy expenditures in August with values of 2500 cal/g and minimal values for December with 200 cal/g. The increased energy expenditure was found in the early hours of the day (daylight hours) and then declined, reaching minimum values at night, with the exception of October, which displayed an inverse pattern. Calorimetric analysis did not show statistically significant difference between the energy provided by sex ($p > 0.05$). Main food energy intake was 4.8 ± 0.3 Kcal g-1 of dry weight, with the total weight of the mexcalpique consisting of, on average, 85.49 ± 2.49% organic matter, and 14.50 ± 2.49% mineral matter. By replacing the caloric values in the energy balance equation, was determined that *G. multiradiatus* uses approximately 81% of the energy consumed in the production of tissue and gametes (P and G), respiration process spent 5.7% (ER) and the rest 13.3% is invested in maintenance (EU and F). Multivariate analysis of environmental factors on the metabolism, showed no significant differences, however the temperature showed the lowest value of significance ($p = 0.08$).

3. *Herinchthys cyanogutattus*

Texas Cichlids were formerly given the scientific name of *Cichlasoma cyanoguttatum*, but are now known by the name *Herichthys cyanoguttatus*. The genus *Herichthys* has been through several changes, and currently consists of nine species, native to lakes and rivers in south Texas and northern Mexico, making them the most northern naturally occurring species of cichlid in the world. It's the only native cichlid in the US and amongst the first cichlids imported to Europe, having first been imported in 1912. This species has also been introduced into areas they are not indigenous to, sometimes on purpose, but often by aquarium owners desperate to divest themselves of a fish the can no longer take care of. The areas of non-indigenous populations range from northern Texas to Florida, where it has become a popular game fish. This is due to having a tasty flavor similar to that of their distant relative, Tilapia.

In Mexico this species is called "Mojarra del norte" and It could be distinguished by a coupled of dark spots and a tiny blue circles on its sides. Adults show a olivaceus iridescent spots when viewed in the sun, there are also lines of the same color on the head, body and fins. During reproduction it is possible to see white region in the front part and a dark in the back especially in females, while males develop a prominent hump.

3.1. Biology

This fish could live in a wide range of temperature, between 5° and 30°C., [25, 26]. Trophic spectrum show variations between each population according to the region but in general is consider an omnivorous fish [27]. Many studies have described aspects of reproduction; the most relevant aspect is the monogamous behavior, when a male select a coupled it becomes aggressive and territorial [28].

3.2. Environmental conditions

The first step in this research was to looking-for a population in order to do the ecological description of its habitat. H. *cyanoguttatus* was found in several places around Queretaro State, but only one was selected due to accessibility. This place is called Taxhido river and is located at 70km E, from the Queretaro capital 20° 35′ 18′′O and 99° 40′ 47′′N, the climate is subhumid with summer rains (Cw1) with an average temperature of 15.1°C, the months of May and June are those with the highest temperatures. The average annual rainfall is 659.5 mm, occurring mainly during the summer and the main contribution to the dam water is from a spring. Sampling was made over a full hydrological cycle (one year, beginning in February) in which the *H. cyanoguttatus* population was monitored once every two months, at the same time physical factors were measure (T°, pH, dissolved O_2, turbidity, depth). The physicochemical parameters of water showed stable behavior during the studied hydrological cycle (pH = 7.4 to 8.2; dissolved oxygen = 4.5 to 8.3 ppm). On the other hand, the temperature was constant between 29 and 31°C., Fig. 4.

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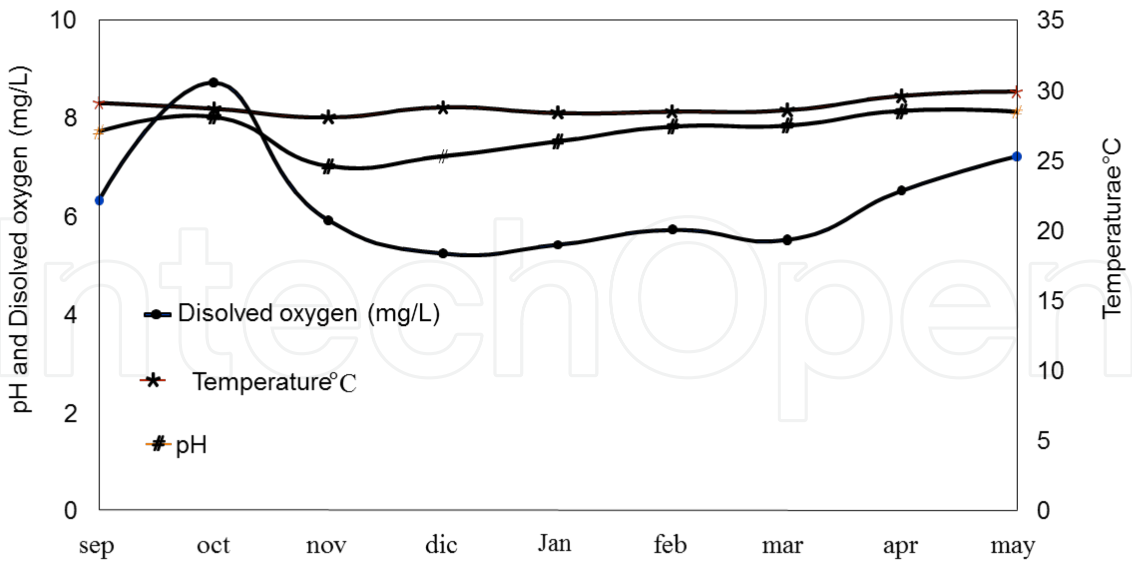

Figure 4. Environmental parameters tendency during an hydrologic cycle in Taxhido river.

3.3. Laboratory studies

Organisms were collected in Taxhido and then transport to laboratory and maintained for acclimation during a month. After this time a group was used to optimal temperature determination and other group for an optimal density experiment.

3.3.1. Optimal temperature

The fish were placed in 15 rectangular glass tanks distributed using a Latin square scheme in order to avoid spatial effects. The tanks´ dimensions were of 0.4.5 m depth, 0.8 m wide and 0.3 m long, with a water storage capacity of 100 L. Five triplicated treatments with 15 organisms were applied using environmental temperature as a medium value, so the treatments were; 24, 26, 28, 30, and 32°C. The handling of tanks involves, the feces removal and partial water change (30%) weekly. The fish were feeding with a commercial diet for Tilapia (Api-Tilapia 1, maltaCleyton® with 50% protein, 12% lipid, 13% ash, 3% fiber, 12 moisture) throughout the experiment. Feeding frequency was adjusted to three provisions offered three times daily starting at 8 AM, 1 PM and 6 PM. The results show that 28°C., is the best temperature for *H. cyanoguttatus*, fig. 5.

3.3.2. Optimal density

Once the temperature was determined a similar experiment was carry out, but in this case the variable was the density. Five densities were probed, T1= 5, T2=10, T3=15, T4=20 ind/per aquarium. It is important to consider that control temperature was implemented in each aquarium in order to avoid an effect for spatial distribution. The results show that 15 individuals is the best density for *H. cyanoguttatus*, table 2.

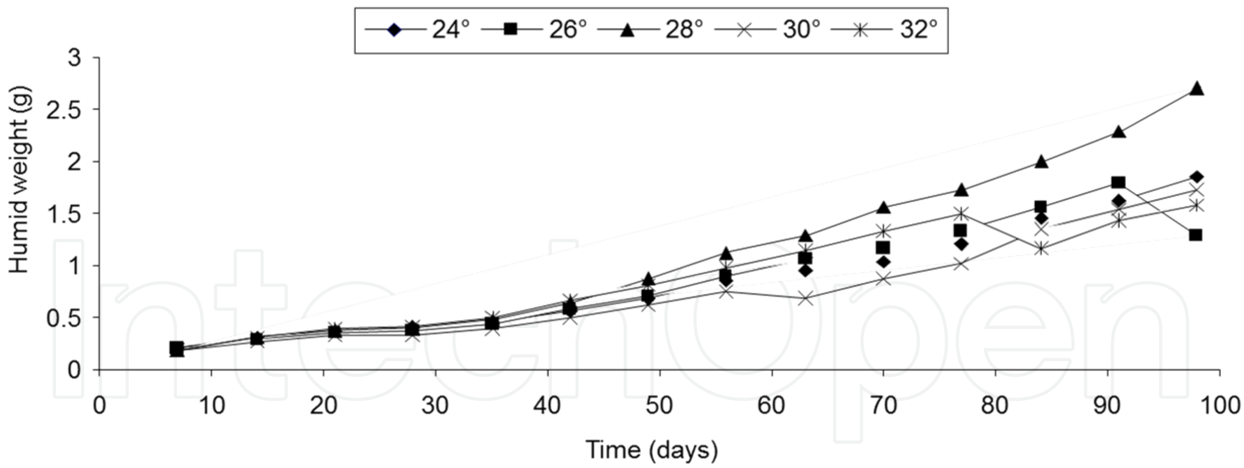

Figure 5. Humid weight behavior for the different temperature treatments

Performance parameters	T1= 5 ind	T2=10 ind	T3=15 ind	T4=20 ind
Initial number (n)	5	10	14	19
Final average number (n)	1	6	9	7
Survival rate (%)	26.66	56.66	61.7	38.88
Initial Total weight (g)	2.16	2.84	4.28	16.92
Initial individual average weight (g)	0.43	0.28	0.29	0.91
Final Total weight (g)	2.36	9.26	14.05	23.81
Final individual average weight (g)	0.59	1.09	1.49	2.05
Weight gain (%)	95.16	293.44	400.59	94.86

Table 2. add caption

3.3.3. Bioenergetics

Aerobic metabolism were determine in natural conditions with a semi closed system with (0.5L) respirometric chambers, using a method which assumes that the reduction of oxygen and the increase of nitrogen in the chamber depend on the weight of the animal, the volume of water, the period of time in which no water circulated in the chamber and the ambient temperature [22]. After each cycle, sample was oven-dried in an electric oven between 70-80°C until the samples had constant weight. From each composite sample 2 g were measured and taken as analytical sample; the samples were digested with concentrated nitric acid. The determination of the percentage proximate composition was chemically analyzed according to the method of analysis described by the Association of Official Analytical Chemist [23].

Physiological experiments showed higher oxygen consume at 15:00 hrs, while a minimum consumption was founded during the morning, Fig. 6.

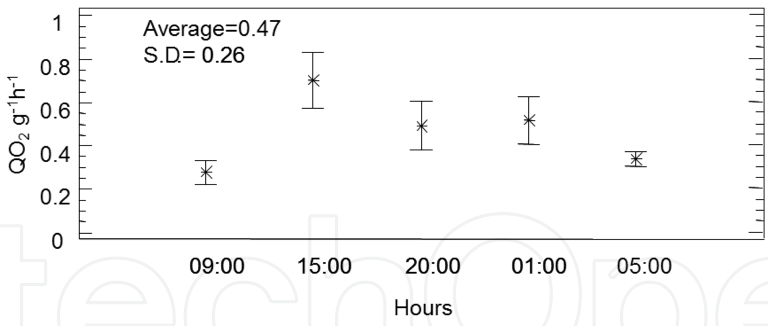

Figure 6. Oxygen consumption in natural condition for *H. cyanogutattus*

After three weeks in laboratory condition (acclimatization) oxygen consumption was measured to know if a metabolism was changed. The results show that higher consumption was found at 15:00 and minimal during the morning so the fish did not show modification in oxygen consumption.

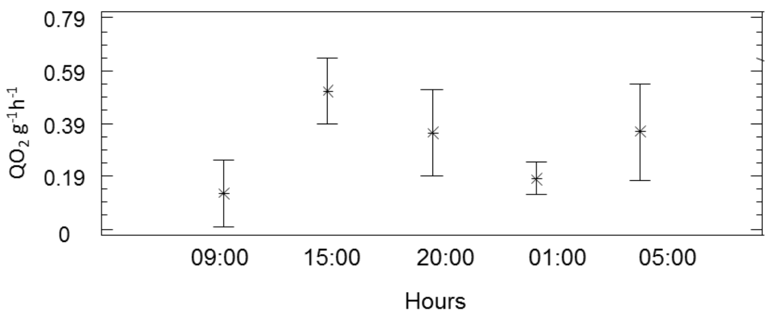

Figure 7. Oxygen consumption under laboratory condition for *H. cyanogutattus*

Finally, oxygen consumption was measured for each of the temperature treatments in order to know in which an alteration occurs. The results show that maximum values for oxygen were founded at T3= 30° minimal at T2 =26° treatments.

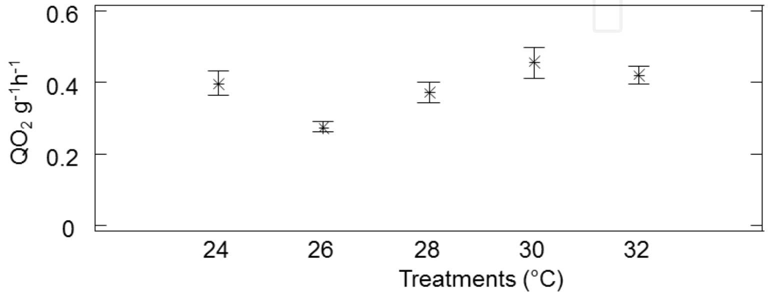

Figure 8. Oxygen consumption for each temperature treatment at the end of the experiment.

4. *Procambarus diguetti*

The cambarids, known in Mexico as acociles (in Náhuatl), makaxil (in Mayan), chapos (in Purépecha), or freshwater crayfish, according to the region, are well known, and were regularly consumed by the Aztecs and other ethnic groups based around the Valle de Mexico already during prehispanic times [29]. *Procambarus digueti* is endemic to the Mexican Central-Occidental Plateau and is found only in certain parts of the Duero and Camécuaro rivers. The Duero River is 10 km long, whist the river Camécuaro is just 2 km long. The two rivers meet at Las Adjuntas. Furthermore, this species is known to occur in Lake Chapala, though samples were collected 40 to 50 years, so is believed to have naturally disappeared from some locations, though these local extinctions may in fact be unnatural This species is threatened by over-exploitation, habitat destruction and degradation, and the introduction of exotic species.These processes have already resulted in reduction in abundance of this species, and the extinction of some populations. Much of the natural habitat of this species has been altered by chemical pollution or by human activities such as canalization, clearing, dredging and embanking of rivers, construction of reservoirs, and the regulation of water levels and stream flows. Furthermore, this species is also threatened by the introduction of exotic crayfish such as *Procambarus clarkii* and *Cherax* species from Australia, which competes for food resources and refuges, and also alters the total production of the native ecosystems (Gutiérrez-Yurrita and Latournerié-Cervera 1999). In addition to over explosion of population, a cultural pressure exists, purepecha people attributes curative properties at *Procambarus* [30].

4.1. Study area

The first part of the experiment was carry out in the national park of Camecuaro lake, which is found in Michoacan State over the municipality called Tangancícuaro, 19°54′10″N;102°12 ′20″O, at 1,700 meters above sea level. The national park has a spring called Camecuaro lake which is the main contribution for Camecuaro river, the depth is between 1.5 a 1.8 m; temperature 17.7 y 21°C; dissolved oxygen 7.3 y 7.5 mg/ L; visibility of 100%; hardness 138.8 y 145.5 mg/L $CaCO_3$. A handled extraction was practice in order to have a desirable sample size for the laboratory work. The organisms were transported in plastic bags with a supplemented oxygen and ice to avoid the over heat.

4.2. Laboratory studies

Acclimatization of organisms was carrying out during a month in glass aquariums considering environmental conditions. The principal problems for the maintenance of the organism were the feed and the density, so in this case these two experiments were carry out.

4.2.1. Establishing the diet

The organism were placed in 15 rectangular glass tanks distributed using a Latin square scheme in order to avoid spatial effects. The tanks′ dimensions were of 0.45 m depth, 0.8 m wide and 0.3 m long, with a water storage capacity of 100 L. Three commercial diets were probed T1= Trucha initial; T2= Camaronina, and T3=Tilapia initical, table 3. The handling of tanks involves, the feces removal and partial water change (30%) weekly. Feeding frequency was adjusted to two provisions offered three times daily starting at 8 AM and 6 PM.

Diet Compounds	**Trucha Iniciador (50:15)**	**Camaronina (35:8)**	**Tilapia Iniciador (32:4)**
Protein (%)	50	35	32
Humidity (%)	12	12	12
Grass (%)	15	8	4
Crude fiber (%)	4	5	10
Ash (%)	12	10	10
Calcium (%)	2	1.4	
Phosphorous (%)	1.2	0.9	
E. L. N.	7	30	

Table 3. Proximal Chemical Composition of the diets tested for growth

Multiple condition factor (K) was calculate for each treatment, with this factor is possible to know the relative health for organisms [31].

$$K = (10^2 * W) / L^b$$

Where;

K= Multiple condition factor

W= Weight

L= Length

b= exponent from $W = KL^b$

The type of growth was determine for the Ricker equation [32];

$$W = aL^b$$

Where;

W=weight

a = intercept

b= slope

As can be seen in

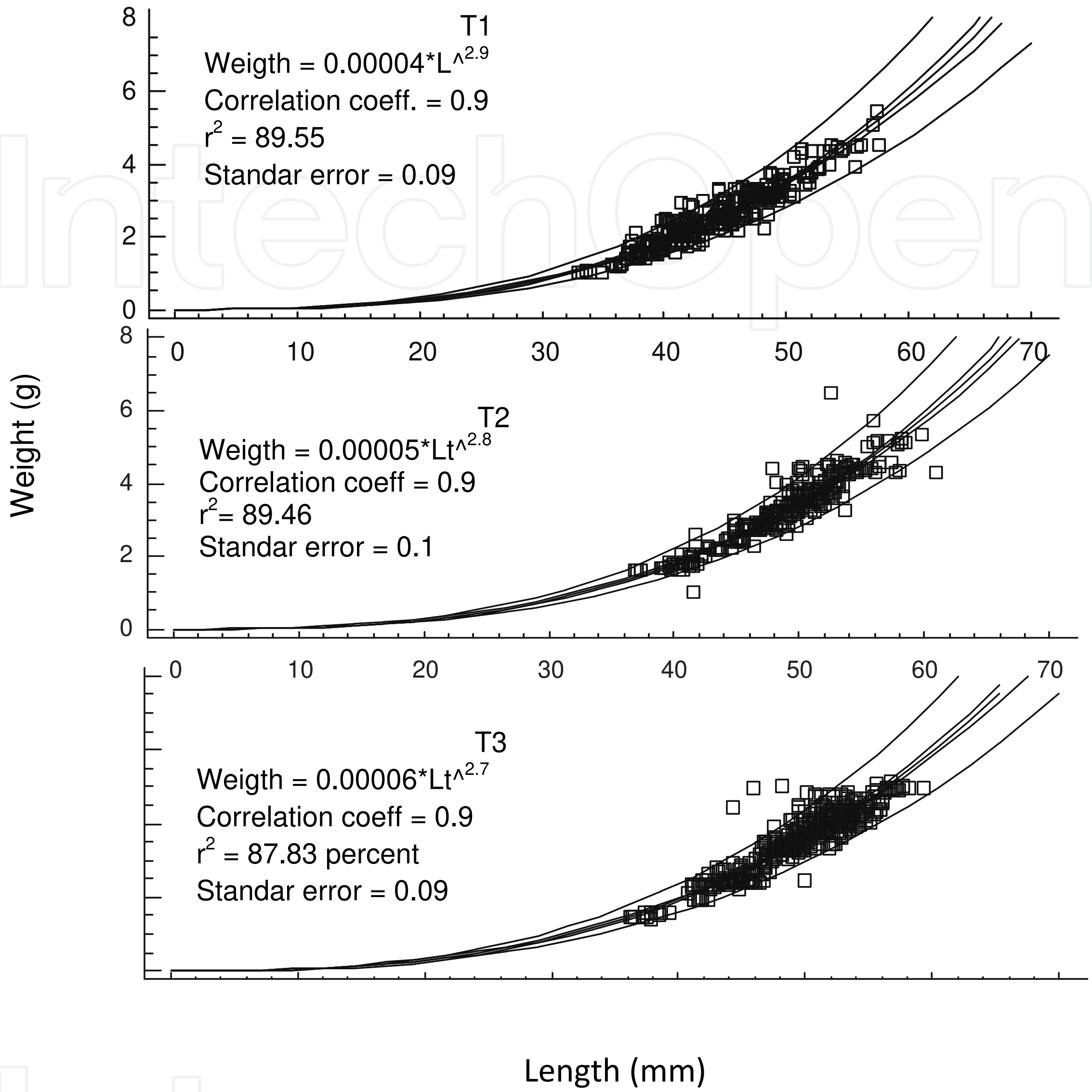

Figure 9. Regression for each one of treatments, values for the equation $W=KL^b$

Aerobic metabolism were determine in natural conditions with a semi closed system with (0.5L) respirometric chambers, using a method which assumes that the reduction of oxygen and the increase of nitrogen in the chamber depend on the weight of the animal, the volume of water, the period of time in which no water circulated in the chamber and the ambient temperature [22]. After each cycle, sample was oven-dried in an electric oven between 70-80°C until the samples had constant weight. After three weeks in laboratory under the diets treatment, oxygen consumption was measured to know if a metabolism was changed. The results show that higher consumption was found at 15:00 and minimal during the morning so the fish did not show modification in oxygen consumption, Fig. 10.

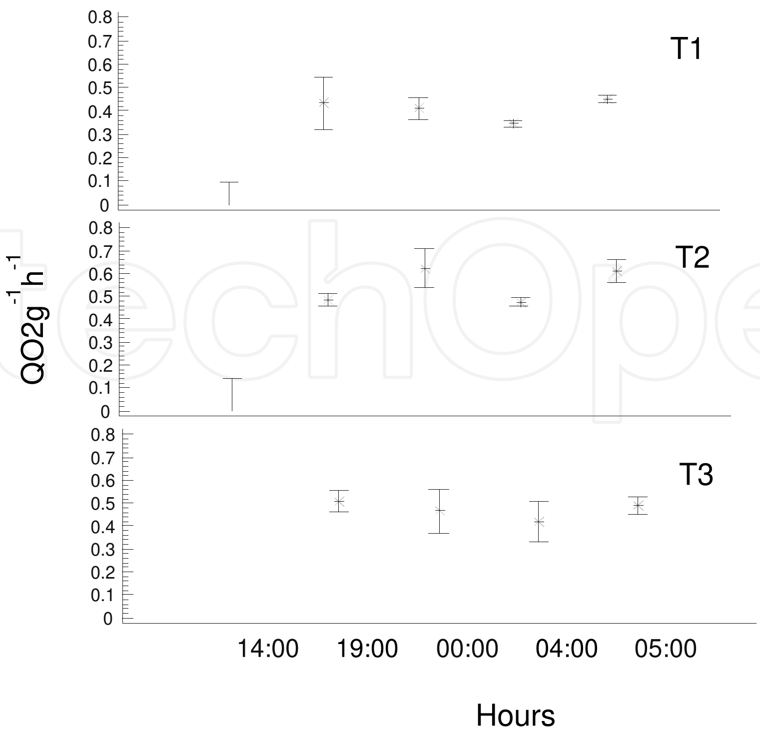

Figure 10. Oxygen consumption for each diet treatment at the end of the experiment

At the end production of total biomass was estimated, the results show that T1 is the best feed for *Procambarus digueti*, and T3 is the diet with a minor biomass production.

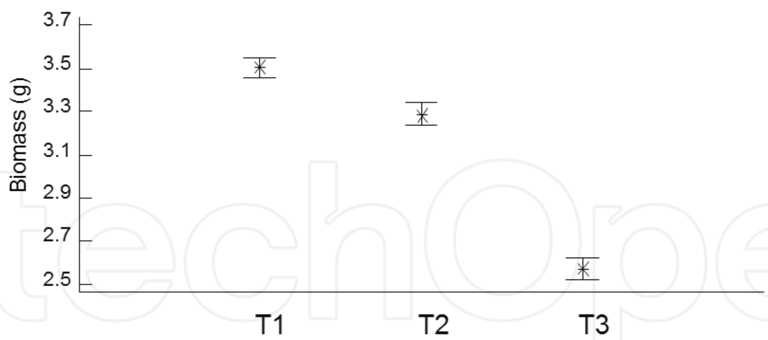

Figure 11. Biomass production at the end of experiment for each of the treatments

4.2.2. Establish an optimal density

The organism were placed in 15 rectangular glass tanks distributed using a Latin square scheme in order to avoid spatial effects. The tanks´ dimensions were of 0.4.5 m depth, 0.8 m wide and 0.3 m long, with a water storage capacity of 100 L. Five densities were probed, T1= 5, T2=10, T3=15, T4=20 ind/per aquarium. The handling of tanks involves, the feces removal and partial water change (30%) weekly. The fish were feeding with a commercial diet for trucha (50% protein, 10% humidity, 12% lipid, 12% ash, 4% fiber, 12% moisture) throughout the experiment. Feeding frequency was adjusted to three provisions offered two times daily at 8 AM, and 6 PM. The results show that a density of 15 organisms is optimal for *Procambarus* growth, table 4.

Treatment	5	10	15	20
Initial number (n)	5	10	15	20
Final average number (n)	5	8	9	6
Survival rate (%)	100	80	60	30
Initial individual average weight (g)	4.8	5.23	5.53	5.18
Final individual average weight (g)	7.12	5.67	6.36	2.82
SGR (%/día)	1.94	1.71	1.83	1.018
Weight gain (%)	612.9	467.2	536	182
Production	0.302	0.158	0.091	0.063

Table 4. Performance growth for the densities treatment in *Procambarus digueti*

4.2.3. Bioenergetics

The flow of energy that was used to determine the energy efficiency and assimilation is show in the next equation:

$$C = P + G + ER + EU + F$$

Where; C is the total energy content of food consumed, P and G are the energy equivalents of somatic and gonadal growth respectively, ER is the energy utilized in respiration, EU is the energy lost as nitrogenous and other waste compounds excreted (50% protein) is the best food for *Procambarus digueti.* The energy balance is show in the table 5.

Diet	C	P	R	U	F
	Consume cal/mg	**Biomass cal/mg**	**Oxygen cal/mg**	**Nitrogen cal/mg**	**Feces g**
Tilapia (32:4)	5423.44	3.664	1.309	0.450	0.014
Camaronina (34:8)	5545.03	3.845	1.175	0.525	0.009
Trucha (50:15)	5706.273	3.873	1.264	0.569	0.006

Table 5. Energetic balance for *Procambarus digueti*

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5. Conclusion

Aquaculture has been supporting human demands for fish products for centuries and is an important industry worldwide. Global production from aquaculture has been increasing steadily, having more than doubled in the last decade; aquaculture now supplies one third of seafood consumed worldwide. With the massive increase in world aquaculture production in 1990s, the current aquaculture industry is one of the fastest growing sectors in world food production. However, the expansion of aquaculture has been accompanied by degradation of the natural environment, especially on marine aquaculture. Directly impacts of fisheries and aquaculture are habitat modification, collection of wild seedstock, changes of food webs, introduction of nonnative fish species and diseases that harm wild fish populations, and nutrient pollution. According to the FAO, major issues that need to be addressed are problems with access to proper technology and financial resources, together with environmental impacts and diseases. Another argues that further increases in aquaculture production will come mainly from further investment in biotechnology. The development of new strategies or technologies does not imply that the old one disappears; to the contrary the main idea is to use the experience and improve existing technology.

These three experiences and review of similar cases that have been developed in Mexico allow us to establish a general methodology in order to know the aquaculture potential for native species.

1. Knowledge.- The first step consist in to know and get the information above the specie. In the case of *G. multiradiatus* the knowledge practically doesn’t exists so the research was oriented to the basic biology and ecology aspects. For example, with *G. multiradiatus* the main objective was to obtain reproduction but to reach these aspects it is required the maintenance under laboratory conditions and for this the knowing of food habits are essential. In the case of *H. cyanogutattus* the main problem was its taxonomic status, so the principal problem to obtain the basic knowledge is that some aspect were publish under the scientific name *Cichlasoma cyanoguttatum* and others aspects with the actual name *Herinchthys cyanogutattus.*

2. Environmental prospections.- It is necessary to know the basic physicochemical parameters (T°, pH, DO_2) in order to establish the strategy for transportation and laboratory maintenance. Field observations and ecological description is necessary in order to know the feeding habits, interspecific competence and the disposition of resources. With these parameters is possible to start the research.

3. Feed.- Under laboratory conditions feeding is the main problem in order to continue so the proofs needed is the acceptance of commercial food. The three species show an acceptance for commercial food but the problem here is the metabolism aspects such as assimilation and performance growth. This kind of problems could be solved with a bioenergetics approach.

4. Bioenergetics.- Ecophysiological basis of species should take into consideration the physiological characteristics and ecological role of the organism in question. Physiological

analysis will reflect the conditions which affect population characteristics, such as population growth, intraspecific competition, and functional and numerical responses. These studies can do more than being simply descriptive, since they enable the development of scenarios that can be tested either through strictly controlled laboratory experiments or field experiments.

The new aquaculture research must be consider to add native species, this work is an effort to get the basic information in order to development of biotechnology and a link between the basic and applied science.

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