Chapter 8 Optimization of the rainbow trout rearing process (O *ncorynclius mykiss*). Case- study

Capítulo 8 Optimización del proceso de crianza de trucha arcoíris (O*ncorynclius mykiss*). Estudio de caso

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Abstract

The rainbow trout (Oncorynclius mykiss), is a species belonging to the Salmonidae family, native to the Pacific coast of North America, due to its easy adaptation to captivity, its breeding has been widely spread almost throughout the world. In Mexico, the cultivation of trout began at the end of the 19th century, in the first natural nursery in Chimea Lerma, state of Mexico, in order to carry out repopulation in national water bodies. There are several species of this fish that can be farmed, but what has achieved the greatest success is the rainbow trout, due to its rapid growth, lower oxygen content in the water, and resistance to disease.

Referring to trout farming in the problems that producers in the Huauchinango region have in terms of overpopulation of specimens in ponds, generating uncertainty in the inadequate distribution of trout affecting their size and weight, it is carried out an extra activity known as "unfolding", which consists of the transfer of trout through a net from a pond that passes through a trout selector who determines the size and destination of each of the specimens, with the aim of dividing them according to to the stages of growth; this operation generates additional costs that are not recoverable at the final point of sale of the specimen, knowing these factors arises the need to optimize the process of rearing and fattening trout by standardizing the ponds, establishing a model to develop a hatchery of trout. Thanks to the results obtained in the analysis of the La Barranca hatchery, the optimal conditions were defined for the design of the hatchery ponds that will be located in the "Piedras Pintadas" river within the region corresponding to the property of the Preeminent Technological Institute of Huauchinango, Puebla, located in Colonia 5 de Octubre of the same city.

Optimization, Process, Rainbow trout, Research, Standardization

1. Introduction

Rainbow trout (Oncorhynchus mykiss), is a species belonging to the Salmonidae family, native to the Pacific coast of North America, which due to its easy adaptation to captivity, its breeding has been widely spread almost all over the world. In South America, it is distributed in Argentina, Brazil, Bolivia, Chile, Colombia, Ecuador, Peru and Venezuela.

Starting in the 1970s, several fish farms or fish farming centers began to be installed, which were built following traditional breeding systems, using concrete ponds; currently in the technical advances and new farming technologies, trout farming has become an alternative for the mass production of fresh fish, as well as for the generation of job opportunities directly and indirectly.

There are several species of this fish belonging to the Salmonidae family, which can be farmed, but what has achieved the greatest success is the rainbow trout, due to its rapid growth, lower oxygen content in the water and resistance to disease.

The cultivation of trout in Mexico began at the end of the 19th century, in the first natural nursery in Chimea Lerma, state of Mexico, in order to repopulate national water bodies. In 1973, the reproduction of rainbow trout was formalized, and by decree, the fish farming center in Salazar was created in the state of Mexico, which in 1943 became the "el zarco" aquaculture center.

In 1950, the aquaculture center in Pucuato , Michoacan began operations, which is currently operated by INAPESCA. The activity is considered profitable; however, it is affected by different crop diseases and in some cases by the lack of good quality and volume of water. The trout farming activity is carried out mainly in areas with temperate to cold climates and in places with an attitude greater than 1,200 meters above sea level (INAPESCA, 2013).

Likewise, rainbow trout is classified as category "E" or "Established space in Mexico" according to NOM-059 (SEMARNAT, 2010).

The Law defines aquaculture as the set of activities aimed at the controlled reproduction, pre-growth and fattening of species of fauna and flora carried out in facilities located in fresh, marine or brackish water, through breeding or cultivation techniques, which are susceptible to commercial, ornamental or recreational exploitation.

However, as has been shown, aquaculture, in addition to being important in providing foods rich in protein, has social and economic importance, its purpose is to support sustainable development, avoiding fishing and environmental overexploitation of aquatic resources; providing alternative or complementary work in the fishing sector and other related activities, especially in fishing regions in crisis or rural areas with a high degree of marginalization; generating roots in the communities of origin, obtaining income, foreign exchange with the goods for use and consumption demanded by developed countries. Referring to trout farming in the problems that producers in the Huauchinango region have in terms of overpopulation of specimens in ponds and as a consequence generates uncertainty in the inadequate distribution of trout affecting the size and weight of the same, generating an extra activity known as "unfolding", which consists of the transfer of trout through a network of a pond that passes through a trout selector that determines the size and destination of each of the trout. specimens, with the aim of sectioning them according to growth stages, it is worth mentioning that this operation results in the generation of additional costs that are not recoverable at the final point of sale of the specimen, knowing these types of factors arises the need for optimize the process of raising and fattening trout by standardizing the ponds by establishing a model to develop a hatchery trout river in the location in the "Piedras Pintadas" river located within the territory belonging to the Higher Technological Institute of Huauchinango.

2. Methodology

2.1 Study area

It is located in the northwestern part of the state. Its geographical coordinates are the parallels 20º 05´ 30” and 20º 17´06” north latitude of the meridians 97º 57´ 00” and 98º 08´06” west longitude. Its boundaries are: to the North with Xicotepec de Juárez and Juan Galindo, to the South with Ahuazotepec and Zacatlán, to the West with Juan Galindo and Tlaola and to the West with Naupan, Ahuazotepec and the State of Hidalgo.

Two climates can be identified in the municipality: humid temperate climate, with rains all year round; average annual temperature between 12 and 18º C; temperature of the coldest month between -3 and 18º C; precipitation of the driest month greater than 40 millimeters, percentage of winter rain with respect to the annual is less than 18. semi-warm sub-humid climate, with rains all year; average annual temperature greater than 18º C; precipitation of the driest month greater than 40 millimeters, percent of rain, winter with respect to the annual less than 18. It occurs in the lower parts of the municipality to the east. The municipality belongs for the most part to the hydrographic basin of the Necaxa River; the extreme northeast to that of the San Marcos or Tecolutla River.

The Necaxa River rises under the name of Totolapa in the south of Huauchinango, runs through steep mountains running through the municipality in a southwest-northwest direction and plunges to the bottom of deep ravines forming the Salto Chico and Salto Grande waterfalls, used in power generation. On their way to the Tenango or Necaxa dams (the last two in Huauchinango territory) they are fed with its waters, collecting the flow of small tributaries and then mighty currents such as the Texcapa, Chapultepec, La Malva, Hayatlaco, Dos Puentes, Xoctongo. , Mazontla, Cuacuila, etc., that bathe the municipality in all directions. Subsequently, the Necaxa River continues to run through the mountains, crosses the territory of Veracruz and, with the name of Tecolutla, flows into the bar of the same name, in the Gulf of Mexico. To the north, the municipality is crossed by the Naupan River, a tributary of the San Marcos, which originates in the Sierra de Pahuatlán and with the name of Cazones, flows into the Gulf. Intermediate between Naupan and the Necaxa, the Alseseca river crosses the north of the municipality, which disappears when it leaves the municipality.

In short, it is a municipality that has a large hydrological flow. (INAFED, ENCYCLOPEDIA OF MUNICIPALITIES AND DELEGATION OF MEXICO)

2.2 Data collection

As referenced in the particularity of Mexican aquaculture is that the information that has been generated is scientifically based which is based on approaches with areas of nutrition, health, physiology and technology. Mitigating the lack of specialized research on historical, economic, or social analysis is reflected in the little or no existing information.

The documents with the greatest content on these topics are from the state or federal development plans, technical reports, statistical yearbooks or informative bulletins, published by the various government agencies in charge of promoting aquaculture and fishing, such as the Secretary of Agriculture, Livestock , Rural Development, Fisheries and Food (SAGARPA), the National Aquaculture and Fisheries Commission (CONAPESCA) and the National Fisheries Institute (INAPESCA), among others.

Due to the scarce and generic information existing by these dependencies, it was established through an analysis of the area to determine the source of information and training on aquaculture to one of the largest predominant producers, the trout farm "La Barranca" located in the community of Teopancingo belonging to the municipality of Huauchinango, Puebla. Developing descriptive research through surveys, according to García Ferrando (1993), a survey is an investigation carried out on a sample of representative subjects of a larger group, which was carried out in the context of daily life, using standardized procedures of interrogation, in order to obtain quantitative measurements of a wide variety of objective and subjective characteristics of the population.

3 Results

3.1 Biological material

Consisting of 10,000 to 15,000 rainbow trout, the population of the trout farm has 8 rectangular ponds of two different sizes according to the size of the specimens.

3.2 Infrastructure

The study sample hatchery has:

1. 3 incubators with dimensions of .615 meters long by .52 meters wide by a depth of .085 meters with a storage capacity of 100,000 to 120,000 eggs.
2. 2 circular ponds for fry stage I with dimensions of 1.8 meters in diameter by 1.2 meters deep.
3. 7 ponds for the juvenile stage II to the adult stage and harvest with dimensions of 15 meters long by 3 meters wide by 3 meters deep.
4. 1 pond for the juvenile stage I which has the dimensions of 10 meters long by 2.5 meters wide by 1 meter deep.

The ponds are structured in a staggered manner by the dimensions of the land, highlighting the conditioning factor of overpopulation in them, generating that in the same pond there are specimens with different sizes, generating the variable to be eliminated of splitting that consists in the transfer of trout through a network of a pond that passes through a trout selector that determines the size and destination of each of the specimens, in order to select them according to growth stages, said operation brings as a consequence the generation of costs for activities that do not generate value to the final product.

3.3 Unfolding operation

Splitting is understood as the correct distribution of rainbow trout specimens, sectioning them according to their size and weight. This operation consists of two activities which are described below:

1. Select: an average of 5 kg of fish is taken with a net and passed through the selector previously calibrated to the correct size and weight specifications, if it is not carried out the specimens do not develop properly, the operation lasts approximately 50 and 55 seconds.
2. Return: once the specimens have been correctly selected by size and weight, they will remain in the pond and those that do not meet these variables will be placed in another pond.

Specimens that do not meet the appropriate size and weight are transferred to a cage in order to standardize them. For the unfolding operation, 2 operators work an 8-hour shift with one meal, generating a base salary of $200 per day. During this operation, about 6 ponds of 2 reproduction stages (juvenile and fattening) are processed.

Juvenile stage: includes specimens between 68 and 100 grams in weight, the number of specimens is 15,000 per pond.

Fattening stage: includes specimens between 100 and 250 grams in weight, the number of specimens is 10,000 per pond.

It was established to measure the time of the splitting operation by inspecting two operators considering the amount of trout in each pond and determining the number of splittings that will be carried out in relation to the average weight that is extracted per sample.

The sample size 333 was calculated for a pond of average size for 10,000 specimens, the following table summarizes the number of samples necessary to select 10,000 trout per pond of a size between 100-250 grams according to the splitting times in select and return operations. See Table 1 Fattening split of 100-250 grams (select) and Table 2 Fattening split of 100-250 grams (return)

∑ fish by splitting = 10792 trout

∑ Time in minutes to select = 292.15

Active minutes / hour = 55 minutes

$$Real\ time\ select\ by\ pond = \frac{\sum time\ in\ minutes\ to\ select}{active\ minutes/hour} = \frac{292.15\ minutes}{55\ minutes/hour} = 5.31\ hours$$

∑ Fish by splitting = 3844 trout

∑ Time in minutes to select = 36.8 minutes

Active minutes / hour = 55 minutes

$$real\ return\ time = \frac{\sum return\ time\ in\ minutes}{active\ minutes/hour} = \frac{36.8\ minutes}{55\ minutes/hour} = 0.67\ hours$$

$$unfold\ time = real\ time\ select + real\ return\ time = 5.31 + 0.67 = 5.98\ hours$$

$$cost\ of\ unfolding\ fattening\ stage = unfold\ time * operator\ cost\ per\ hour * number\ of\ ponds$$

$$cost\ of\ unfolding\ fattening\ stage = 5.98\ hours * \frac{200}{8} * 2\ operators * 3 ponds = \$\ 897$$

3.4 Juvenile stage

The same procedure was carried out to determine the sample size, which was 251 for a tank with a capacity for 15,000 specimens, establishing a size between 68-100 grams in relation to the unfolding times in the selection and return operations, obtaining the following results:

3.4.1 Operation Select

∑ Fish by division = 15291 trout

∑ Time in minutes to select = 220.36

Active minutes / hour = 55 minutes

$$real\ time\ select = \frac{\sum time\ in\ minutes\ to\ select}{active\ minutes/hour} = \frac{220.36\ minutes}{55\ minutes/hour} = 4.01\ hours$$

3.4.2 Return Operation

$\sum$ Fish by splitting = 5953 trout

$\sum$ Time in minutes to select = 26.41 minutes

Active minutes / hour = 55 minutes

$$real\ return\ time\ = \frac{\sum return\ time\ in\ minutes}{active\ minutes\ /hour} = \frac{26.41\ minutes}{55\ minutes/hour} = 0.48\ hours$$

$$unfold\ time = real\ time\ select + real\ return\ time = 4.01 + 0.48 = 4.49\ hours$$
$$cost\ of\ unfolding\ fattening\ stage = unfold\ time * operator\ cost\ per\ hour * number\ of\ ponds$$
$$cost\ of\ unfolding\ juvenile\ stage = 4.49\ hours * \frac{200}{8} * 2\ op * 3ponds = \$\ 673.5$$

$$total\ unfolding\ cost\ = cost\ of\ unfolding\ fattening\ stage + cost\ of\ unfolding\ juvenile\ stage$$

$$total\ unfolding\ cost = \$897 + 673.5 = \$1570.5$$

According to the results obtained, the cost of carrying out the unfolding operation in 6 tanks of two different stages is $1570.5

$$monthly\ unfolding\ cost = total\ unfolding\ cost * unfold\ number\ per\ month$$

$$monthly\ unfolding\ cost = 1570.5 * 2 = \$3141$$

The monthly cost for the unfolding operation corresponds to $3141

$$annual\ unfolding\ cost = monthly\ unfolding\ cost * 12\ meses$$

$$annual\ unfolding\ cost = \$3141 * 12\ months = \$37692$$

As it could be demonstrated, executing the unfolding operation periodically twice a month throughout the year will have an annual cost of $37,692.00 for an activity that does not generate value in the production process, but nevertheless it is necessary to carry it out. Due to the overpopulation of specimens in each of the tanks, the calculation of the cost generated by the splitting activity has the purpose of optimizing the process by eliminating the splitting operation.

4. Conclusions

Using the results of the study carried out at the La Barranca hatchery, the optimal conditions for the design of the hatchery ponds were determined, which will be located within the territory belonging to the property of the Higher Technological Institute of Huauchinango, Puebla, located in Colonia 5 de Octubre de the same city.

This location is located at 1601 meters of altitude, we can also find within it an influx of water derived from a river. The corresponding plant facilities (ponds) that are intended to be developed in the project will be located within the premises of the Higher Technological Institute of Huauchinango, specifically at latitudes 20°09'35.7" North and 98°02'23.6" West (20 °09'35.7"N 98°02'23.6"W).

According to the needs for the incubation of eggs and development of fingerlings, the incubation room and fingerling ponds must be established (see annex 1) within an infrastructure protected from variations in environmental temperatures, the door should preferably be located in the north façade to prevent the entry of sunlight. For the installation of an incubation room and fingerling ponds, the use of an area of 10.9 mx 5.4 m is projected, having a total area of 58.86 m.

To cover the needs of the fattening stage, three ponds with dimensions of 8.8m *4.4m *1m each are established (see annex 2)

6 References

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Boards

Table 4 Fattening split of 100-250 grams (select)

Fattening split of 100-250 grams (select)				
Sample number	time(s)	unfold weight	Average by unfolding	Fish by unfolding
1	50	5	173	29
2	51	5	227	22
3	50	5	229	22
4	52	5	182	27
5	51	5	145	3. 4
6	54	5	181	28
7	50	5	147	3. 4
8	54	5	142	35
9	51	5	157	32
10	53	5	151	33
323	55	5	216	23
324	54	5	203	25
325	50	5	217	23
326	54	5	139	36
327	52	5	238	21
328	50	5	128	39
329	50	5	247	20
330	54	5	100	50
331	54	5	247	20
332	53	5	149	3. 4
333	54	5	153	33

Source: Self Made

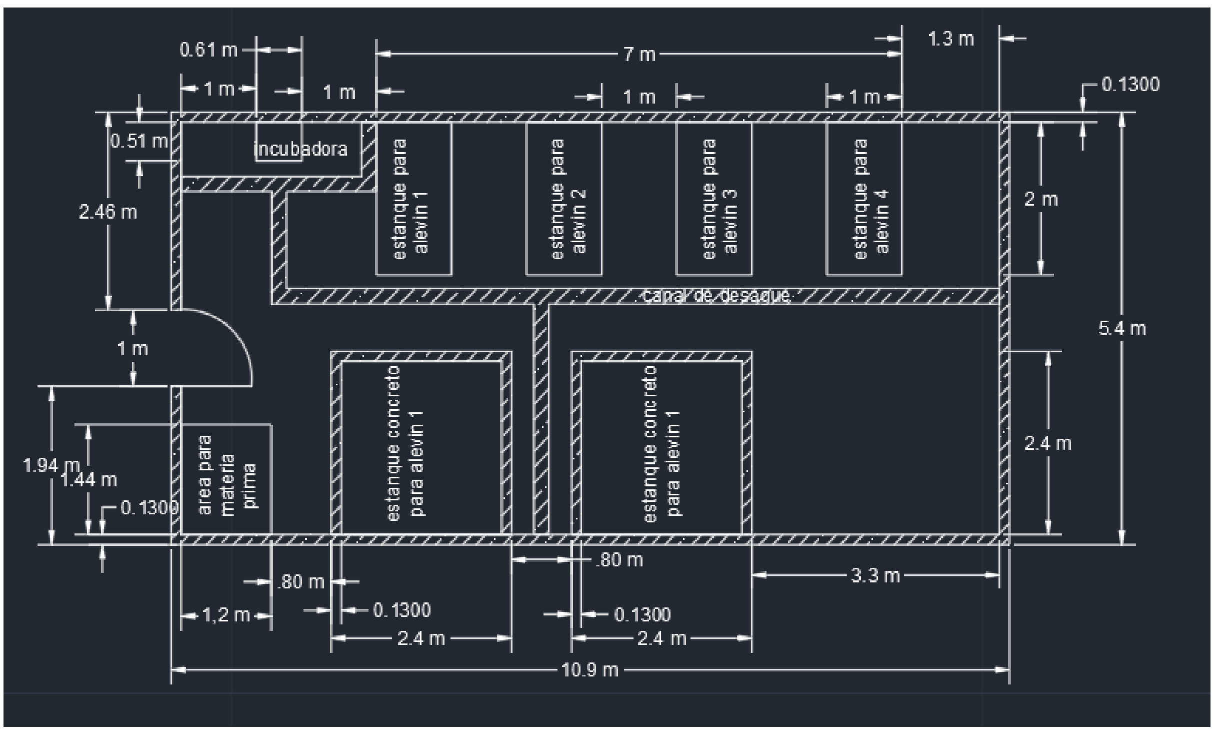
Table 2 Unfold fattening of 100-250 grams (return)

Fattening split of 100-250 grams (select)				
Sample number	time(s)	unfold weight	Average by unfolding	Fish by unfolding
1	52	16.00	110	145
2	47	16.00	174	92
3	41	18.00	161	112
4	53	13.00	210	62
5	46	16.00	124	129
6	54	18.00	126	143
7	50	18.00	220	82
8	40	13.00	119	109
9	52	14.00	198	71
10	53	17.00	248	69
36	50	14.00	216	65
37	51	16.00	124	129
38	48	13.00	107	121
39	41	17.00	143	119
40	44	17.00	142	120
41	53	13.00	182	71
42	52	15.00	186	81
43	50	15.00	199	75
44	53	13.00	226	58
45	46	17.00	242	70
46	47	16.00	176	91

Source: Self Made

Annexes

Appendix 1



Appendix 2