STOCKING DENSITY-DEPENDENT GROWTH AND SURVIVAL OF NILE NILAPIA
(Oreochromis niloticus) IN CAGES AT SON FISH FARM, BUIKWE DISTRICT

BY

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JULY, 2018
DECLARATION

I, ABESIGA LUCAS declare that all the work presented in this dissertation is original and has never been submitted to any university or institution for the award of any degree.

Signature: ...........................................  Date: 15th Oct 2018
APPROVAL

I, the undersigned confirm that this dissertation has been submitted for examination with my approval.

Signature

DR. EFITRE JACKSON

Date 15/08/18
DEDICATION

I dedicate this dissertation to my lovely parents Mr. Businge Stephen and Mrs. Nalubega Resty who have been there for me both financially and spiritually during my academic journey.
ACKNOWLEDGEMENTS

My special thanks go to my academic research supervisor Dr. Efitre Jackson, for his endless efforts toward accomplishment of my research right from the time of proposal writing to completion of the dissertation.

I am grateful to SON fish farm staff and management most especially the production manager Mrs. Allen Kusasira, Mr. Odokonyero Sunday, Mr. Bolingo John Metal for accepting carryout my research as well as accessing the farm’s data and records.
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ABSTRACT

Both low volume high density cages and high volume low density cages are being used by most fish farmers to culture Nile tilapia (*Oreochromis niloticus*) on lakes, dams, rivers and earthen ponds. Choosing the most suitable cage type is one of the factors that lead to successful cage culturing of Nile tilapia.

The study was conducted to determine the most suitable cage type when rearing Nile tilapia. Ten cages were selected for each cage category to determine the survival and specific growth rates of fish. LVHD cages were of dimensions 2.5x2.5x2.5M stocked at stocking of 148 fish/m³ made of a metallic frame and nylon nets and the HVLD cages were of dimensions 6x6x6M stocked at 78 fish/m³ made of plastic frame and nylon nets.

The overall objective of the study was to provide information on the appropriate stocking density practices when rearing Nile tilapia in cages.

Ten cages from each cages were selected at random - from cages being harvested and their survival and growth rates determined and also secondary data was collected from farm production records for the year 2017.

The results of the study showed that HVLD cages had a significantly higher (p<0.05) specific growth rate (SOR) than LVHD cages. There was no significant different (p>0.05) in mean survival rate between the two cages categories.

Physico-chemical water parameters on Lake Victoria at SON fish farm did not vary affects survival and growth rates of Nile tilapia since there within the suitable and safe ranges for their proper growth and survival in cages.

The significant difference in mean specific growth rate of the two cage categories was clue to difference in levels of competition for food, space available for the fish as a results of difference in stocking densities. The mean survival did not show significant difference due to the fact that fish in both cage categories experienced uniform dissolved oxygen, pH and temperature since physico-chemical parameters did not vary on Lake Victoria at SON fish farm during the study.

The results of the study demonstrated that HVLD cages are the most suitable when rearing Nile tilapia fish because they had significantly higher specific growth rate and a slightly higher survival rate than LVHD cages.
CHAPTER ONE

1.0 Background

Fish production from wild stocks has generally stagnated, with most fisheries already fully exploited or over-exploited (FAO 2009) and this has led to a gap between fish production and demand as such capture fisheries can no longer satisfy the ever increasing population of fish consumers.

Feeding an expected global population of 9 billion people by 2050 is a demanding challenge that engages researchers, technical experts and leaders the world over (World Bank 2013) and increasing world fish production is one of the available options to overcome the challenge.

The global decline in aquaculture creates a need for aquaculture expansion (Gabriel 2007) in order to bridge the gap between production and demand. There is a big potential for aquaculture in Uganda owing to the fact that 18% of the county total area is covered by water (Isyagi, 2001). On realizing this opportunity and basing on the policy statement No. 9 which states that, ‘Aquaculture fish production will be increased so as to reduce the gap between fish supply and increasing demand for fish’ (MAAIF, 2004), the Ugandan government is encouraging and promoting aquaculture through ponds and cages.

Since 2006, cage aquaculture has increased in Uganda, mainly in response to the low production from pond aquaculture and SON fish farm is one of the modal farms that is currently producing Nile tilapia using both LVHD and HVLD cages.

Through fish cage farming in Uganda has been existing and the results are promising mostly in rearing Nile tilapia, aquaculture development and output is still very minimal evidenced by the fact that aquaculture contributes only 6% of the total annual fish production of Uganda (FAO, 2014).

The low rate of cage aquaculture development and output is mainly attributed to the fact that most fish farmers in the country lack knowledge concerning cage culture on appropriate stocking density of fish and this leads to low output of cage aquaculture.

Stocking density plays a crucial role in determining the growth and survival, fish and ultimately the overall fish production from aquaculture systems (Sahoo, 2010) and this creates a need to provide the appropriate information to the fish farmers concerning stocking density.
of Nile tilapia in cages. The information currently available on the density-dependent rearing performance of Nile tilapia in ages in Uganda is limited and if the proposed prospects on aquaculture are to be attained. Immediate intervention is needed. This study will determine the best cage to rear Nile tilapia by comparing growth and survival of Nile tilapia in LVHD and HVLD cages at SON fish farm limited on lake Victoria in Buikwe district.

1.1 Problem statement

Due to decline of fish production in Uganda, the government is encouraging and promoting commercial aquaculture mainly cage aquaculture using both LVHD HVLD cages. Fish farmers continue to face low yields of fish from cage aquaculture resulting in low profit margins. This setback originates from lack of sufficient knowledge on the best practices of fish stocking densities in cages that would maximize production. This study aimed at determining the optimal stocking density by comparing growth and survival of Nile tilapia in cages at SON fish farm on lake Victoria.

1.2 Objectives

1.3 General objective

To provide information on the optimal stocking density the Nile tilapia (Oreochromisniloticus) in cages at SON fish farm, Lake Victoria.

1.4 Specific objectives

1. To determine the physical-chemical parameters (Temp. Do, pH) within cages site
2. To determine growth and survival rates of Nile tilapia in the LVHD and HVLD cages at SON fish farm.

1.5 Justification

This study aimed at providing knowledge to the fish farmers and the concerned department of aquaculture management and development on the appropriate stocking density of Nile tilapia fish in LVHD and HVLD cages in order to achieve high survival and growth rates of the fish. This will bring the use of cages when rearing Nile tilapia in a more profitable way so as not to
make loses due to inappropriate stocking of Nile tilapia in the cages and this will lead to aquaculture development in the country.

1.6 Research questions

1. Do physical-chemical parameters the two cages categories.

2. Does variation in physical-chemical parameters affect growth and survival of the Nile tilapia in the cages?

3) Are there differences in growth and survival rates between LVHD and HVLD cages?
CHAPTER TWO

3.5 Literature review

Besides, the impact of land usability on the profitability of aquaculture, stocking density is believed to affect growth and survival of the fish species stocked (Bwanika Gladys et al. 2014)

According to the study conducted by Ntazi and colleagues (2014), increasing stocking density of Nile tilapia beyond 2670 fry/m3 significantly affected survival and growth rates of Nile tilapia in hapas submerged in earthen ponds.

Effects of stocking density on fish growth

The effect of stocking density is usually seen to be either density dependent or density independent. The stocking density that affect fish growth rate is density dependent, Wiener et al. (1982)

Stress as a result of stocking density

According to Bacellos et al. (1999), found that stress leads to increased cortisol production by even resting plasma and these increases with increasing stocking density. Their results indicated that higher cortisol concentrations are considered as chronicle response to social stress due to high stocking density and affects fish growth due mobilization of dietary energy by physiological alteration cause by stress.

In the study of the effect of stocking density on growth and yield of Nile tilapia in cages on Lake Kirifu in Ethiopia, Mengistou and colleagues (2008) reported that growth showed a significant difference with increasing stocking density (p<0.05) but survival was not affected by stocking density.

WiratJiwyam et al. (2014), growth and survival are inversely related to density and high stocking density has no significance difference on growth and survival.
CHAPTER THREE

3.1 METHODOLOGY

3.2 Study area

The study was conducted at SON fish farm located in Njeru sub-county in Buikwe district in eastern Uganda that deals in homo sex production of Nile tilapia fish in cages for commercial purposes on lake Victoria.

Figure 1: The Source of the Nile fish farm physical address
3.3 Research design

Ten cages were selected from each cage category randomly from the cages being harvested at SON fish farm on Lake Victoria. The fish harvested from each cage were counted and the number recorded.

Secondary data was collected from production records on when the cages were stocked and the date cages were stocked.

The LVHD cages were of dimensions 2.2x2.5x2.5 m and stocked at 146 fish/m$^3$ whereas the HVLD cages were of dimensions 6x6x6 m and stocked at a density of 78 fish /m$^3$

The fish in all cages were reared for six months and fed on the same on manufactured pelled feed diets of varying pellet sizes depending on the stage of fish growth and fed 6 time a day.

Three sampling points for physico-chemical parameters monitoring were selected and included upstream, mid stream and downstream

3.4 Data collection

3.5 Determination of physical-chemical parameters

Physical chemical water parameters (DO, water temperature and pH) were determined in situ weekly using a multi-parameter water probe model NO: MW600 smart at 8:00 am and 4:00pm

3.5 Determination of survival and growth rates of Nile tilapia fish in the two cage categories

Ten cages for each category were selected randomly from those being harvested and their survival and growth rates determined

HVLD cages were of dimensions 6 x6 x6 x6 meters and those of LVHD cages were of 2.5 x 2.5 x 2.5 x2.5 meters.

3.6 Survival rate

Survival rate was determined using the formula below
Survival rate = $\frac{\text{No. of fish harvested}}{\text{No. fish stocked}}$ x 100
Additional historical data concerning survival rates of Nile tilapia in two cages for various stocking densities previously used was collected from SON fish farm’s production records.

### 3.7 Determination of specific growth rate (SGR) of Nile tilapia fish in the two cage categories under various tested stocking densities

Specific growth rate (SGR) will be calculated as follows:

\[
\text{SGR (\% per day)} = \left( \frac{\ln W_f - \ln W_s}{T} \right) \times 100\%
\]

Where: \(W_f\) = Final weight of fish; \(W_s\) = Weight of fish at Start; \(T\) = Duration of rearing fish in the cages

### 3.8 Statistical data analysis

The survival and specific growth rate data was transformed using arsine transformation in order to normalize and the mean survival and specific growth rates (±SE) were computed for each cage category.

Statistical differences in mean SGR and survival rates between the two cages categories were analyzed using Independent T-test.

All data analysis was done using SPSS computer program (p≤0.05).
CHAPTER FOUR

4.0 Results

4.1 Physico-chemical parameters

The values of Physico –chemical water parameters (dissolved oxygen, temperature and pH) were computed into mean ± standard error for each selected sampling points as shown in table 1.

The mean physico-chemical parameters did not vary at any selected sampling point and were in range with those recommended for proper growth and survival of nile tilapia.

Table 1: Mean ± standard error of physico-chemical parameters of selected sampling points

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Upstream</th>
<th>Mid stream</th>
<th>Down stream</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temp( °c )</td>
<td>22.25±1.1</td>
<td>22.28±1.2</td>
<td>22.23±1.2</td>
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<tr>
<td>Dissolved oxygen</td>
<td>5.92±1.2</td>
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<td>5.90±1.2</td>
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<tr>
<td>Ph</td>
<td>8.12±0.6</td>
<td>8.10±0.5</td>
<td>8.10±0.5</td>
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</table>
4.2 Survival rate

Nile tilapia in HVLD cages showed a slightly mean higher survival rate (M=89.16) than LVHD cages (M=84.61) as presented in figure 2.

There is no statistical significance difference in the mean of the two cage categories at ( p >0.05, t=3.76 )

Figure 2: mean survival rates of the two cage categories
4.3 Specific growth rate (SGR)

There is was a significantly significant difference in mean specific growth rates (SGR) of the two cage categories at( t=14.6), ( p<0.05) with HVLD cages having a significantly higher specific growth rate of nile tilapia (M=1.75) than LVHD cages (M=1.65) as represented by figure 3.

Fig 3: Variation in mean specific growth rate between HVLD and LVHD cages
CHAPTER FIVE

5.1 Discussion of results

5.1 Physico-chemical parameters

In this present study, different physico-chemical parameters of water in the cage were within the suitable and safe ranges for mono-sex tilapia growth and survival throughout the study period.

The range of water temperature (26.0 °C to 31 °C) in the experimental cages is in agreement with Boyd [19], who proposed that the range of water temperature from 26 °C-31 °C is suitable for tropical fish culture. Similarly, Dan and Little [11] suggested that tilapia is suitable for raising between April and December when temperatures range from 25 °C to 35 °C.

Oxygen is the most important stress factor which has direct impact on health and survival of caged fish. For optimal growth, dissolved oxygen (DO) levels should be above 5 mg/L for warm fish species. Throughout this study, dissolved oxygen ranged between 6.3-7.8 mg/L and mean pH was also in range with the suitable and safe range for culture of Nile tilapia.

5.2 Survival rate

The significance similarity in mean survival rates of the two cage categories is due to the fact that all the cage categories experienced similar condition of water qualities of dissolved oxygen, water temperature and pH since there was no fluctuation hence the fish in all cage categories survived at the same rate irrespective of fish being stocked at different densities and occupying different space (Beveridge MCM, 1996).

High volume low density (HVLD) cages had a slightly higher survival rate than that of low volume high density cages because they offer enough space for the fish to swim freely due to large volume of cages hence fish these cages experiences less stress, less competition for oxygen and food unlike the fish in the later cages which are highly stocked, occupying less space due to low volume of the cages hence this means the fish are highly stressed, experience greater competition for space, oxygen and higher aggressiveness for food.[1]

The main limiting factor causing a slight difference in the mean survival rates of the two cage categories is stress. Stress plays a crucial negative role in the mortality of fish in cages in a...
way that fish experiencing higher stress levels are highly susceptible diseases and parasites and eventually some die hence lowering the survival Barcellos[2]

5.3 Specific growth rate

Difference in mean specific growth rate between the two cage categories is due to a number of limiting factor which are mostly density-dependent in nature.

Among the limiting factors of specific growth rate of Nile tilapia in cages, stress is the most important. According to Barcellos (1999), stress increases with increase in stocking density.

Stress impairs growth of fish in cages in a way that it leads to increased cortisol production by even resting plasma and higher cortisol concentrations are considered as chronicle response to social stress due to high stocking density and this impairs fish growth due mobilization of dietary energy by physiological alteration. Stressed fish usually show reduce response to feeds and hence less energy for growth and overall poor feed conversion efficiency. (Beveridge MCM (1996).

In this study, fish in HVLD cages showed a higher specific growth rate because they experienced less stress resulting from stocking density as compared to higher stress experienced by fish in LVHD cages hence accounting for significance difference in mean specific growth rates of the two cage categories.

Aggressiveness for food is also one of limiting factors impairing growth of fish in cages where by when aggressiveness levels are high, less energy is converted into weight of fish flesh as the fish spent it struggling and fighting for feeds. Wiener [10]

Fish in HVLD cages showed higher specific growth rate than those in LVHD cages because they have low aggressiveness levels due being fewer in a larger volume of the cages unlike fish LVHD cages which struggle and fight when feeding due to being many in a smaller volumes of cages resulting into lower specific growth rates.

Competition for oxygen is another major limiting factor responsible for the significance difference in mean specific growth rate of fish in the two cage categories. Oxygen acts as fuel in the aerobic oxidation of food in the fish’s body to release energy for growth and maintenance of life processes. Ntazi [8].
CHAPTER SIX

6.1 Conclusions and recommendations

6.2 Conclusion

High volume low density cages (HVLD) had higher mean survival and growth rates than low volume high density cages.

Physico-chemical parameters did not vary between the two selected cage categories.

6.2 Recommendations

Basing on the results from this study, I recommend fish farmers interested or intending to rear Nile tilapia fish in cages on lakes, rivers and dams that it’s better they adopt or choose to use HVLD cages for the best results in of fish survival and growth rates which will lead to a more successful and profitable aquaculture.

Basing on the fact that different fish markets prefer different sizes of fish, I also recommend that the best way to stock fish in cages is to consider the size of fish your market prefers. For markets which prefer smaller or medium fish weighing averagely 250 – 400 g, LVHD cages can be the best choice but for markets requiring bigger fish weighing averagely 500- 1000g, HVLD cages is the best option.
References


APPENDICES

Group Statistics

<table>
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<tr>
<th>CAGES</th>
<th>N</th>
<th>Mean</th>
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<td>84.6190</td>
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Appendix 1

Independent Samples Test

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Group Statistics

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Appendix 3

Independent Samples Test

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