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THE INFLUENCE OF DIFFERENT MUSICAL STIMULATION ON THE GROWTH RATE OF KOI CARP (*Cyprinus carpio*)

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INTRODUCTION

http://www.youtube.com/watch?feature=player_embedded&v=ZS_6-IwMPjM#t=73

The word music originally '*mousike',*by way of the Latin *musica,* was used to mean any of the arts or sciences governed by the Muses in the Ancient Greek era. Later, in Rome, *arsmusica* embraced poetry as well as instrument-oriented music. The concept of musica was split into four major kinds by the 5th century philosopher, Boethius: musica universalis, musica humana, musica instrumentalis, and musica divina. Of those, only musicainstrumentalis referred to music as performed sound (WIKIPEDIA: Definition of the music).

Music is hard to define. For some, any sort of noise could be music, while musician Cage says, "There is no noise, only sound." (KOZINN, 2012) According to musicologist NATTIEZ (1990), "The border between music and noise is always culturally defined, which implies that, even within a single society, this border does not always pass through the same place; in short, there is rarely a consensus. By all accounts, there is no *single* and *intercultural* universal concept defining what music might be."

What we definitely know is that music was always a need to the human race. This can be justified by the prehistoric findings from paleolithic archaeology sites. The earliest and largest collection of prehistoric musical instruments was found in China and dates back to between 7000 and 6600 BC (WILKINSON, 2000), although the Divje Babe flute, carved from a cave bear femur, is thought to be at least 55,000 years old. Flutes are often discovered, carved from bones in which lateral holes have been pierced. These are thought to have been blown at one end like the Japanese shakuhachi. Instruments such as the seven-holed flute and various types of stringed instruments, such as the Ravanahatha, have been recovered from the Indus Valley Civilization archaeological sites (MASSEY and MASSEY, 1976). Music was an important part of social and cultural life in Ancient Greece (800 to 140 BC). Musicians and singers played a prominent role in Greek theater (SAVAGE, 2012) were mixed-gender choruses performed for entertainment, celebration, and spiritual ceremonies (WEST, 1994).

In the 20th century, with such a great improvement in technology, music became more reachable through the increase of radio stations, easier distribution of recorded music and the internet. Besides the increase of music listeners, the 20th century was characterized by the exploration of new rhythms, styles and sounds, which gave music another aspect and an increasing number of genres.

Classical music, strictly defined, means music produced in the Western world between 1750 and 1820. This music included opera, chamber music, choral pieces, and music requiring a full orchestra. To most, however, the term refers to all of the above types of music within most time periods before the 20th century. In its limited definition, classical music includes the works of Haydn, Mozart and Beethoven. From Mozart alone, there are a huge range of pieces to enjoy, as he wrote symphonies, music for quartets and quintets, chamber orchestra pieces, choral pieces, piano concertos, and entire operas. In total, he wrote over 600 musical pieces (WISEGEK: What is the classical music).

Mozart produced many serenades, the 13th of which, nicknamed '*Eine kleine Nachtmusik'* beautifully optimizes the "high classic style". The four-movement work opens with a bright allegro in sonata form, and then a slow, lyrical second movement follows. The third movement is a light minuet, and the finale is a brisk rondo (EINE KLEINE NACHTMUSIK).)Each movement of 'Eine kleine Nachtmusik' provides a microcosm of style and form of the late 18th Century musical style (NEW YORK UNIV.).

Chill-out music is a general term for several styles of electronic music characterized by their mellow style and mid-tempo beats. "Chill" being derived from a slang injunction to "relax."Chill-out music emerged in the early and mid-1990s in "chill rooms" at dance clubs, where relaxing music was played to allow dancers a chance to "chill out" from the more emphatic and fast-tempo music played on the main dance floor.

The genres associated with chill-out are mostly ambient, trip-hop, nu jazz, ambient house, New Age and other sub-genres of down tempo. Sometimes the easy listening sub-genre lounge is considered to belong to the chill-out collection as well. Chill-out as a musical genre or description is synonymous with the more recently popularized terms "smooth electronica" and "soft techno" and is a loose genre of music blurring into several other very distinct styles of electronic and lo-fi music. A number of compilations with "Chill-Out" in their titles were released in the mid-1990s and beyond, helping to establish the genre as being closely related to down tempo and trip hop but also incorporating, especially in the early 2000s, slower tempo varieties of house music, nu-jazz, psybient, and lounge music of approximately 80 to 110 bpm . The genre also includes some forms of trance music, ambient music, and psychoidelectic music, and it has entirely subsumed the older genre Balearic Beat, although that term is still used interchangeably with chill-out.

Chill-out is generally tonal, relaxing (or at least not as "intense" as other music from the styles it draws from), although when used to describe the music played in chill-out rooms at raves, it can also encompass extremely psychedelic experimental sounds of great variety. (WIKIPEDIA: CHILL-OUT MUSIC).

For centuries, music and medicine have been linked together. The Greeks believed that music had the power to heal the body and the soul, as reflected in their mythology, with Apollo - the god of music, giving rise to his son Aesculapius - the god of healing and medicine (ENTREPRENEUR). In the 20th century research about the power of music on humans as well as on non human species has given rise to more solid facts. Research in this field is still ongoing.

REVIEW OF THE LITERATURE

Physiological and psychological effects of listening to music have been documented in humans. The changes in physiology, cognition and brain chemistry and morphology induced by music have been studied. Montreal Neurological Institute researcher SALIMPOOR at al. (2011) have now shown that the pleasurable feelings associated with emotional music are the result of dopamine release in the striatum, the same anatomical areas that underpin the anticipatory and rewarding aspects of drug addiction.

Music is not just an audible medium. Deaf people can experience music by feeling the vibrations in their body, a process that can be enhanced if the individual holds a resonant, hollow object. A well-known deaf musician is the composer Ludwig van Beethoven, who composed many famous works even after he had completely lost his hearing. Recent examples of deaf musicians include Evelyn Glennie, a highly acclaimed percussionist, who has been deaf since age twelve, and Chris Buck, a virtuoso violinist, who has lost his hearing. This is relevant because it indicates that music is a deeper cognitive process than unexamined phrases, such as, "pleasing to the ear", suggest. More research in music cognition seeks to uncover these complex mental processes involved in listening to music, which may seem intuitively simple, yet are vastly intricate and complex (WIKIPEDIA: Music, recognition and psychology).

Effects of music have been proven on both animals and plants. Experiments on plants proved that, when these were left to grow with a musical background having a 60 beats per minute pattern, they grew faster and more efficiently than the ones with rock music in the background. The ones being exposed to rock music withered and died. Plants are living but not thinking organisms, therefore what matters for their development is not the melody, but the rhythm of the music (CLASSICAL FORUM).

Special pieces of music with the right balance of rhythm and melody helped hens lay more eggs and The Yealands Wine Estate 's owner, Yealands, stated that his hens laid larger eggs when he began playing the works of Mozart, Bach and Strauss in the hen houses (CLASSICFM). Classical harp music is used around the world to help alleviate stress and heal sickness in cats, dogs, chimpanzees and other animals. Even in animal shelters music is being introduced to create a more serene environment. Studies show that dogs and cats prefer classical music. Cats will relax in front of the speakers when classical music is playing, and dogs will actually bark less - especially when listening to the music of Bach (MUNCIEARF). Cows exposed to music revealed higher milk yields. A research about milk production and music by MACK (Groton, NY) suggested that when listening to soothing music, cows raised their production by up to 3%. Music with a slower beat, like classical and folk music, relaxed the cows and lowered their stress levels, helping them let their milk down more easily (FEKETE, 2012). An experiment on laboratory rats revealed that mammals have a natural predisposition towards music. An experiment on mice with Bach's Air on the G string in one box, and rock music in another was setup. Most rats chose to go in the box with Bach's music, even when the music was switched from a one box to the other. Later, the rats were placed in a maze, and the ones which chose Bach's music, found the exit before, and more easily than the ones which were exposed to rock music. When scientists then observed the rats' brains, they could see that the ones being frequently exposed to classical music, had a physically more developed brain than the ones who were not being exposed to the particular music (SCIENCENTER). Another experiment FEKETE et al. (2012) revealed that, in the case of humans and rats, a musical environment might improve the learning capacity and spatial intelligence.

Fish are other living organisms which have been exposed to music. The first scientific series of experimentation has been made by FAY (1970). Using goldfish (*Carassius auratus*) detected a fine discrimination and generalization capacity to the auditory frequencies. A few studies have found a response by fish to noise. Naïve goldfish have altered their pattern of locomotion avoiding sounds at 30 cm distance (~2 kHz) and an intensity of 2 dynes/cm^2 (0.2 Pa) (FHWA). According to a study by IMANPOOR et al. (2011) goldfish can distinguish music from other environmental stressful sounds. BANNER and HYATT reported greater growth rate and fry survival of two minnow species (*Cyprinodon variegates* and *Fundulus similes*) held in quieter tanks. However, the level of noise required to have this effect on growth was greater than that normally encountered with traffic. Juvenile Atlantic salmon have shown an avoidance of low frequency sound (10 Hz), but failed to show a response at a higher frequency of 150 Hz. Simulated sonic booms have caused startle reactions in guppies. Trout and salmon eggs and fry exposed to sonic booms showed no increase in mortality and there was no apparent difference in the development of fry. The importance of road noise in affecting the behaviour of fish populations, particularly the relationship between road traffic levels and any response is not known (FHWA).

Results from the sound experiment by Courtney Smith showed that certain sounds and vibration make the betta flare up. With certain types of music, the betta would stay on the side where the music was coming from. These sounds and vibration calm the betta fish (SMITH, 2013).

Sea bream have a fine "ear" for music, being particularly fond of softly played piano melodies. Experiments are under way in southern Japan using music for "systemized fish management." It will be something like a cattle ranch. Artificially bred fish will be raised for the first few months until this process becomes a reflex action for them to associate certain sounds with food. When they are fully grown, the lilting melody will sound one last time. The fish will congregate - only to find they are the food. Various tests established the sea bream's predilection for piano music - a rather low sound in the 200 to 300 Hz range, played at between 50 and 60 decibels. By comparison, squid, another Japanese favorite, responds to sounds of 600 to 700 Hz at 15 to 30 decibels (FHWA).

A study by PAPOUTSOGLOU et al. (2010) on *Cyprinus carpio* (50.5 ± 0.36 g) which were reared in a recirculating water system und 80 and 200 lux and subjected to no music at all (control, ambient noise only), 4 h of Mozart's ‘Eine kleine Nachtmusik’, or 4 h of anonymous ‘Romanza-JeuxInterdits’ for 106 days was carried out. Both music treatments resulted in increased growth performance at both light intensities, with Romanza treatment at 200 lux resulting in better growth performance than Mozart treatment.

A study by PAPOUTSOGLOU et al. (2013) of two musical stimuli transmissions (Mozart and Romanza) and a control group. Both music stimulated groups resulted in significantly higher growth performance in juvenile (6.7 ± 0.12 g) rainbow trout (*Oncorhynchus mykiss*) reared for 14 weeks. Carcass chemical composition and fatty acid composition (% of total fatty acids and mg/g carcass wet weight) did not differ among experimental treatments. The same was observed with regard to liver composition.

Another study by VASANTHAEt al. (2003) on the influence of music on the growth of koi carp, showed that the growth of fish subjected to music was statistically significantly higher.

Information about the potential benefits of music to animals suggests that providing music may be used as a means of improving the welfare of animals, such as through environmental enrichment, stress relief and behavioural modification. Carps (*Cyprinus carpio*) in the trials of CHASE (2001) not only were able to discriminate between John Lee Hooker (guitar and vocals) and Bach's oboa concertos, but also generalized to classical music and blues-pop rock, independently from the artists and ensemles. Recently SHINOZUKa et al. (2013) published results about the 'music understanding' of the goldfish (*Carassius auratus*). They were able to discriminate between Bach's 'Toccata and Fugue in D minor' (BWV 565) and Stravinsky's 'The Rite of the Spring', but the generalisaion and reinforcement (preference) were not consistent.

With very few studies on the influence of music on the Koi carp, I decided to take this study to a further level and introduce a new genre of music together with the already studied classical piece and evaluate any possible statistical significance. For more details concerning the Kois fish in Hungarian see PÉNZES and TÖLG (1986).

After having reviewed the relevant information, it turned out that data about the effect of music on fish is scarce and contradictory. Therefore we developed the following working plan.

1. Does music as an environmental enrichment influence the growth rate in Koi carp?
2. Does classical music influence the growth rate in Koi carp?
3. Does modern chill out music influence growth rate in koi carp?
4. Is there any difference between growth rates when Koi carp are exposed to classical and chill out music?

The above hypothetical questions gave rise to my study. A previous study byVASANTHA et al. (2003), was done on Koi carp to compare the growth rate between a group of koi enriched with classical music and a control group. Their study showed a higher growth rate in the music exposed group.

The aim of my study was to verify if classical music really enhances the growth rate in Koi carp. I also wanted to verify if, classical music or music in general may change the behaviour, growth rate and body composition of Koi carp, therefore a third group with chill out music was included (As a so-called positive control) to compare results.

Since there are a number of factors that could influence the growth rate, constant conditions were kept inin all three tanks. All three tanks had equal water volumes, had same filtration systems with equal filtration rates and flow rates, equal light periods, same temperatures, equal number of fish per tank and equal feed intake. All three tanks were insulated to keep constant temperatures as well as to avoid noise pollution.

OWN INVESTIGATIONS

Materials and Method

Experimental animals

A total of thirty Koi carp bred and raised in Hungary (Average Live Weight13.86 g and Average Total Length 9.6 ± 2.1 cm) were used (**Fig. 1**). They were approximately six months old at the start of the experiment. The fish were selected according to their patterns and colorations for easier recognition. Three groups were needed for this experiment. Ten fish per group were randomly selected.


Fig. 1

Equipment

All the equipment was bought cautiously, keeping the fish welfare in mind. Three IBC 1000 litres tanks on a wooden pallet and a metal frame were bought (**Fig. 2**).


Fig. 2

The top part of the tank was cut open for easier access and handling of fish.

Since the experiment was set up in a garden during the cold months of February to May, fiber wool insulation material of thermal conductivity: λD = 0.039 W/mK, expanded polystyrene blocks of 4mm and plastic film were bought to insulate the tanks (**Fig. 3 and Fig. 4**). The insulation was done both to keep a constant temperature and to provide sound insulation. The tanks had a top cover made out of a metal frame and insulation material and a top lid out of the same insulation material was made (**Fig. 5**)


Fig. 3


Fig. 4


Fig. 5

All the three tanks had a filtration system installed. This was a homemade system made up of an 800 ltr/hr pump in each tank which pumped water into an expanded polystyrene fish box containing very fine cotton wool as the first mechanical filter, then 3 sponges of increasing densities as mechanical and biological filters. Small ceramic balls were included in the last section of this filtration system to serve as biological media (**Fig. 6**).


Fig.6

The tanks were also fitted with 2 x 300 Watts submersible heaters. A photoperiod of 14 hours from 6 am till 8 pm was provided by an 11 Watt energy saver bulb enclosed in an outdoor waterproof casing (**Fig. 7**)

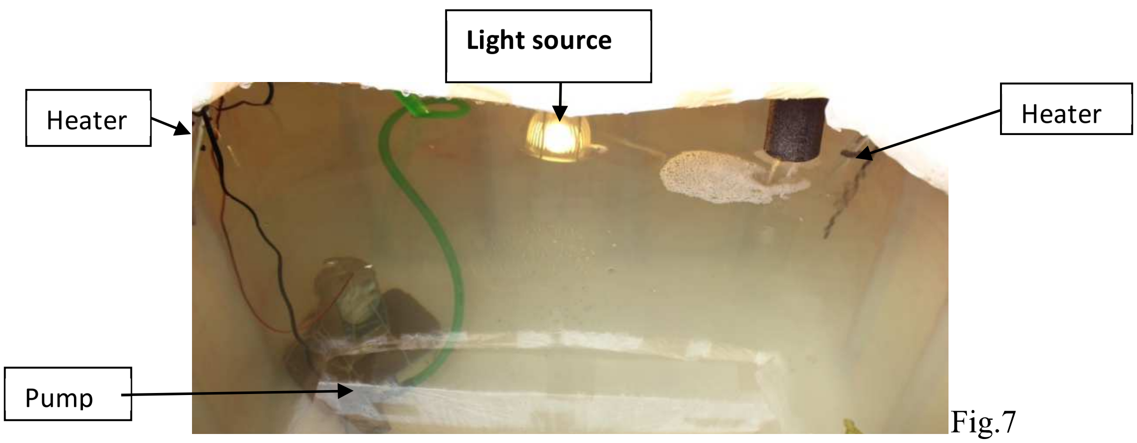


Fig.7

Two out of three tanks had speakers installed. The speakers, from a plug in set were closed in their casing which was filled with sand to keep at the bottom. Speaker was made water proof by sealing it all round with aquarium sealer and covered tightly with plastic film (**Fig. 7**). Each speaker was connected to a laptop, which were kept indoors. The laptops were preset to wake up, play the 1 hour long music piece and sleep again automatically three times daily (**Fig. 8**).

Fig. 8

Other materials used included a 0.01g accurate digital scale used to measure the daily feed ration and the weekly fish weight, plastic measuring cups which were used to measure the exact feed ration, a twenty cm long plastic ruler to measure the fish length, a ribbon to measure the girth, clove oil which was used to anesthetise the fish while taking measurements, an expanded polystyrene fish container used while measuring the fish, a fish net and a bucket (**Fig. 8, 9 and 10**).


Fig. 9


Fig. 10

Methods

All the three insulated tanks were filled with tap water. The vital biological bacteria needed to avoid the new tank syndrome were taken from a mature cichlid aquarium and poured into each of the filtration system (as suggested by *Ferenc Baska*). The tanks were still cycled for 1 week without fish to allow the maturation of the required nitrifying bacteria. A monitoring process was carried out during this week to make sure everything was working fine i.e. the automated music was checked, the timers were checked, the 14 hour lighting period was checked and temperature was controlled regularly.

Once this week was over, the fish were introduced into the tanks. The fish were left for a week to acclimatize to their new environment with new conditions and to reduce any stress induced after transport and handling during selection and measurement taking. During this week no music was played. When the week was over, the fish were caught and their measurements, including weight girth and length were taken. At this stage no anesthetic was used and the fish were quite difficult to handle and measure. I wanted to keep stress levels as low as possible and avoid any limiting factors, which might influence my results and therefore I contacted *Ferenc Baska* who suggested using clove oil to anesthetise the fish during the procedure.

Once I had all measurements at hand, I measured the feed ration at 4% body weight and prepared the feed into plastic cups for the whole week. The fish were fed twice daily at 12 hours intervals i.e. at 7 am and at 7 pm. The feed ration was modified weekly according to the change in weight. 4% body weight was given. Sera Koi Royal pelleted food was used throughout the experiment with declared 6.4% moisture, 9.3% ash, 7.2% ether extract, 32% crude protein and 5.6% crude fibre. The feed was analysed and the actual figures of the 'Approximate Analysis' read, 6.54% moisture, 5.3% ash, 5.1% ether extract, 32.4% crude protein and 1.9% crude fibre.

The third week was when the music was introduced. A speaker in a water proof case was submerged in Tanks A and B and connected to 2 separate laptops. Tank A had chill out music played, Tank B had 'EineKleineNachtmusik' by Mozart played and Tank C was the control tank with no music. The music was automatically played for an hour three times daily at five hours interval i.e. at 7.30 am, at 12.30 and at 5.30 pm. During this hour the filtration system was switched off to eliminate any noise in all three tanks. At the end of the week the fish were caught anesthetized by using the suggested clove oil (30 drops in 15 liters water) and had their measurements taken. The clove oil worked perfectly and no signs of distress were shown in the fish. The fish took about 10 to 15 minutes to start swimming actively again. Once the fish were active and swimming normally again, they were put back in their respective tanks.

During the 14 week experimental period I measured the length the weight and the girth of the fish from which the weight/length/girth gain was derived and weight/length/girth growth rate and specific (syn. instantaneous or true) weight/length/girth growth rate (S.G.R.%) was calculated using the following formulae (BRODY, 1945; LAWRENCE and FOWLER, 1997):

$$G.R.\% = \frac{W2 - W1}{W2} \text{X } 100 \qquad S.G.R.\% = \frac{Ln\, W2 - Ln\, W1}{t} X\ 100$$

Where W1 = initial body weight, W2 = final body weight and T = time elapsed in days

All the data was derived or calculated by using Microsoft Windows Excel 2007 software. All data was logged and saved on an Excel worksheet. Besides the above information, the feed given was also recorded from which the weekly feed increase and the Feed Conversion Ration were derived. Using the data collected a number of graphs were plotted for easier monitoring and interpretation of the results.

I was told not to make any water changes during the experimental period. Unfortunately, when the fish started to grow and more feed was being fed, the water quality started to deteriorate. The filter media were still in good shape and no change was required but a 50% water change was performed on the 12thweek.

The IMAGES BELOW show some steps through the process. **Fig. 11** shows the anesthetized fish, **Fig. 12** shows the selection of fish according to pattern and colour, **Fig. 13** shows me measuring the length, **Fig. 14** shows how the fish weight was measured, **Fig. 15** and **Fig. 16** show the girth measurement and recovery from anesthesia and **Fig. 17** shows the food ration preparation.

Chemical and Statistical Analyses. Ethical Issue.

The major chemical composition of feeds and total fish body composition was determined according to the AOAC (1990). For statistical analysis, the data were processed by the Microsoft Office 2011 Excel software and evaluated with the help of the STATISTICA10 (2012) program. Two-way ANOVA was applied to examine the interactive and main effects of different musical stimuli on dependent variables. Differences between means were analysed by Tukey's least-square means comparison (PETRIE and SABIN, 2005). Differences were generally considered significant at $P < 0.05$.

This experiment has been accepted and allowed by the Ethical Committee of the Veterinary Faculty Budapest (MÁB), under the number of 22.1/2877/3/2011.


Fig. 11


Fig. 12


Fig. 13


Fig. 14


Fig. 15


Fig. 16


Fig. 17

RESULTS AND DISCUSSION

Throughout the fourteen weeks, all the measurements were input in a Microsoft Excel sheet. The length, girth and weight were measured for each fish weekly. These results were used to derive; the weekly gain, the percentage growth rate and the specific growth rate. The feed given and the weekly feed increase were also noted and the feed conversion ratio (syn. feed conversion efficiency) was calculated. Graphs were drawn from the collected data, making the results more visible and easy to interpret.

In the **Figures** below the data collected and the data calculated are shown together with the derived graphs.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	Week #		Fish Number	7	9	10	13	14	17	24	26	29	30		
2															
3	1	9/2/13													
4															
5		Length in cm		9.0	11.7	9.7	9.7	11.5	9.0	8.0	10.1	11.0	9.0	98.7	
6		Girth in cm		5.6	7.6	6.9	6.4	7.4	5.9	5.6	6.4	7.6	6.1	65.5	
7		Weight in grams		9.03	22.56	13.15	14.08	21.37	11.72	9.28	13.80	19.73	9.90	144.62	
8															
9	2	16/2/2013													
10															
11		Length in cm		9.80	12.10	11.00	10.50	12.00	10.20	9.20	10.60	11.80	9.50	106.7	
12		Girth in cm		5.70	7.60	6.90	6.50	7.60	6.20	5.70	6.50	7.10	5.80	65.6	
13		Weight in grams		8.82	21.40	14.75	14.61	22.04	12.96	9.71	14.20	20.87	10.87	150.23	
14															
15	3	23/2/2013													
16															
17		Length in cm		10.50	12.10	11.10	10.50	12.00	10.10	9.40	10.60	12.00	9.90	108.2	
18		Girth in cm		6.00	7.60	7.30	6.90	7.60	6.90	5.60	6.50	8.10	5.90	68.4	
19		Weight in grams		9.94	21.74	14.84	14.84	21.67	13.06	9.17	13.81	22.18	10.57	151.82	
20															
21	4	2/3/13													
22															
23		Length in cm		10.90	12.30	11.50	10.50	12.30	10.10	9.50	11.00	12.20	9.90	110.2	
24		Girth in cm		6.10	7.90	7.50	7.00	8.10	6.90	5.90	7.10	8.40	6.20	71.1	
25		Weight in grams		11.00	22.80	16.11	16.02	23.97	14.08	10.06	17.75	27.17	11.49	170.45	

Tank A / Tank B / Tank C / Graphs / SWGR vs. time / SLGR vs. time / Weight and length vs. time / SWGR% vs. Feed increase / G

Fig. 18 showing the data input of the weekly measured measurements.

P	Q	R	S	T	U	V	W	X
Weight gain	Length gain	Weight growth rate %	Length growth rate%	Specific weight growth rate %	Specific length growth rate %	Feed given	Feed increase/week %	FCR
						5.78	0.00	
	8.00		8.11		1.11			
5.61		3.88		0.54		6.01	3.88	1.03
	1.50		1.41		0.20			
1.59		1.06		0.15		6.07	1.06	3.78
	2.00		1.85		0.26			
18.63		12.27		1.65		6.82	12.27	0.33

nk A / Tank B / Tank C / Graphs / SWGR vs. time / SLGR vs. time / Weight and length vs. time / SWGR% vs. Feed increase / G

Fig. 19 showing the derived and calculated readings.

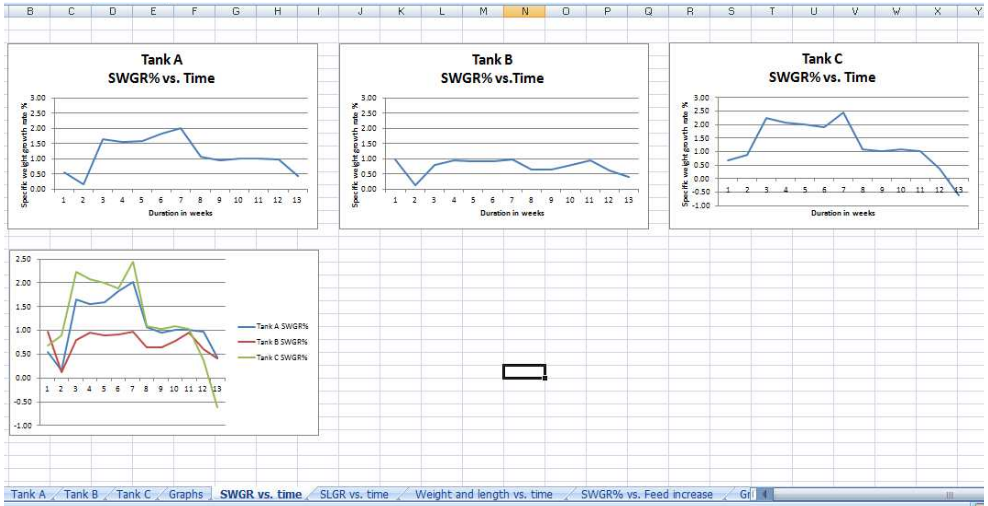


Fig. 20 showing the **s**pecific **w**eight **g**rowth **r**ate % for each tank and a graph comparing the SWGR% of the 3 graphs.

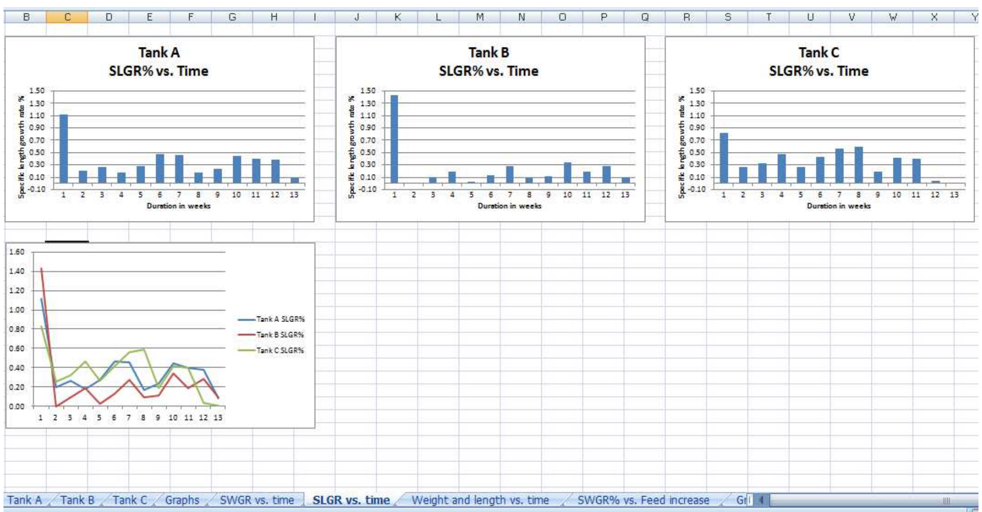


Fig.21showing the **s**pecific **l**ength **g**rowth **r**ate % for each tank and a graph comparing the SLGR% of the 3 graphs.

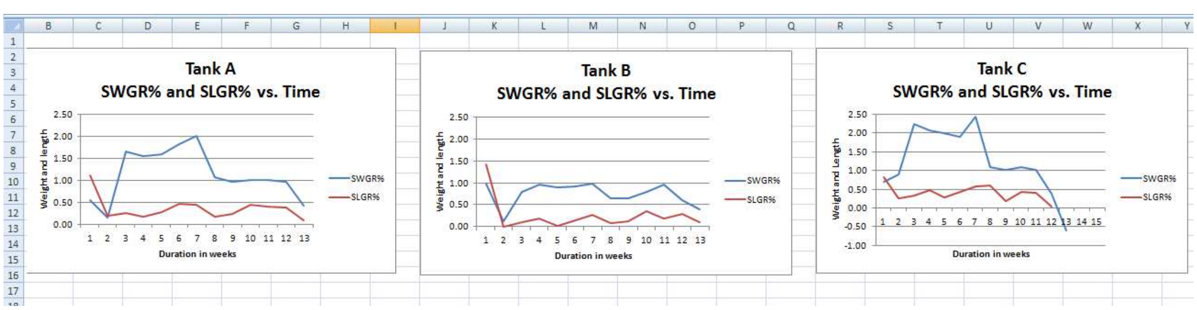


Fig. 22 graphs comparing the SWGR% to SLGR%.

From the data I collected a statistical data analysis by Statistica 10 software was performed by the help and contribution of *Gabriella Korsós*.

From the analysis 12 graphs were chosen to represent the main statistical differences. The groups of graphs chosen were the statistical difference at week 14, that between week 1 and week 14 – representing the statistical difference from start to end, the statistical difference between week 1 and week 2 – the changes during the acclimatization period and the one between week 2 and week 3 – showing the changes as the music was introduced.

In the analysis of variance of Koi data, marked effects are significant at $p < 0.05$.

The three graphs below show the variance based on the data collected on the 14th week. The length, girth and weight versus the group are shown and the statistical p-values are shown next to each corresponding graph.

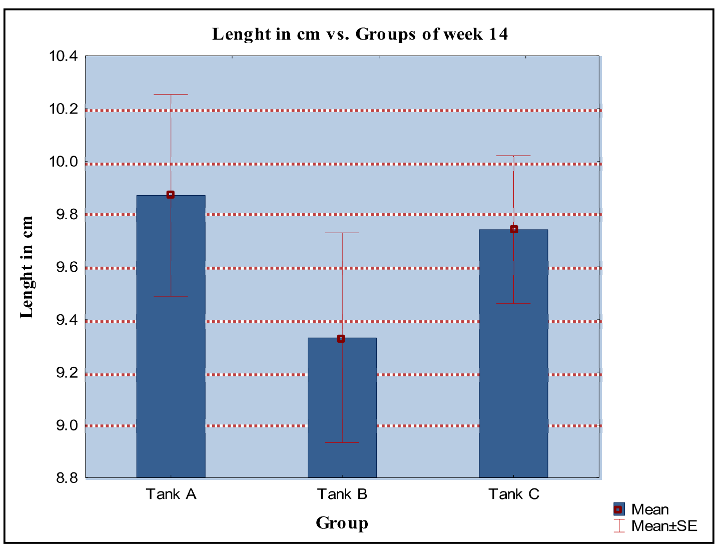


Figure 23a

	Tank A	Tank B	Tank C
Tank A		**0.022279**	0.988678
Tank B	**0.022279**		**0.030959**
Tank C	0.988678	**0.030959**	

Figure 23b

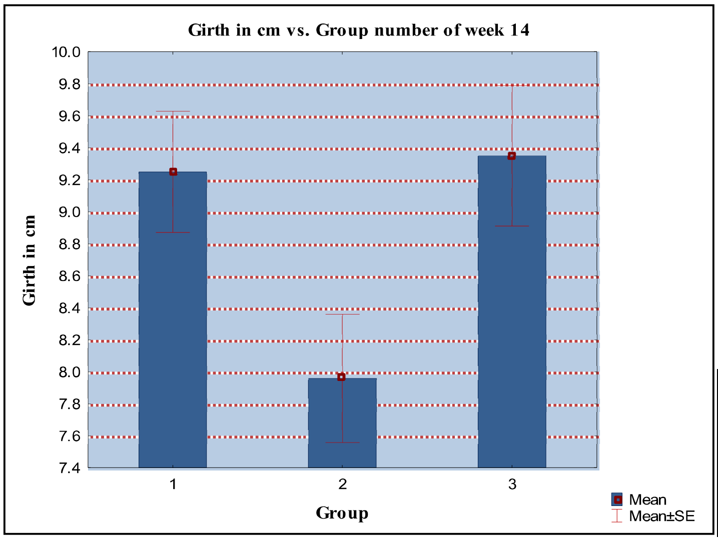


Figure 24.a

	Tank A	Tank B	Tank C
Tank A		0.082673	0.983623
Tank B	0.082673		0.057765
Tank C	0.983623	0.057765	

Figure 24.b

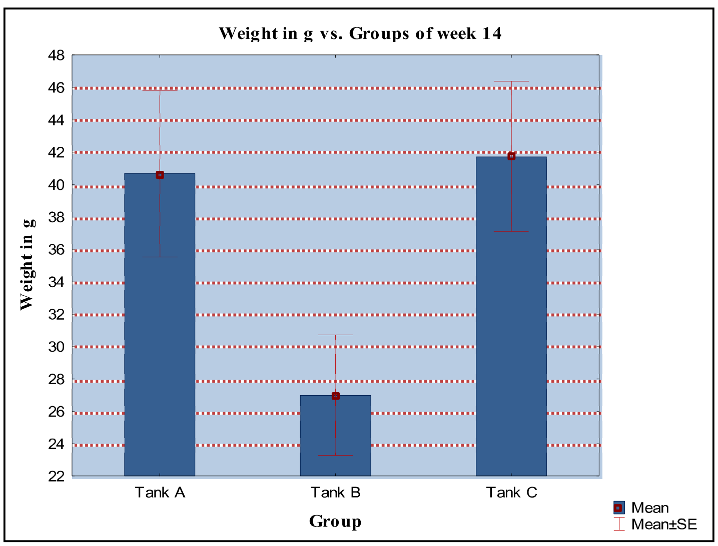


Figure 25a

	Tank A	Tank B	Tank C
Tank A		0.101455	0.985252
Tank B	0.101455		0.072943
Tank C	0.985252	0.072943	

Figure 25b

The above graphs show that there are significant differences in length. A significant difference between Tank A and Tank B (p= 0.022279)can be seen. Between Tank B and Tank C a significant difference (p = 0.030959) was also noted. There are no significant differences in girth and weight.

The three graphs below show the statistical variance based on the comparison of the data collected on week1 and week 14. The specific length, girth and weight versus the group are shown and the statistical p-values are shown next to each corresponding graph.

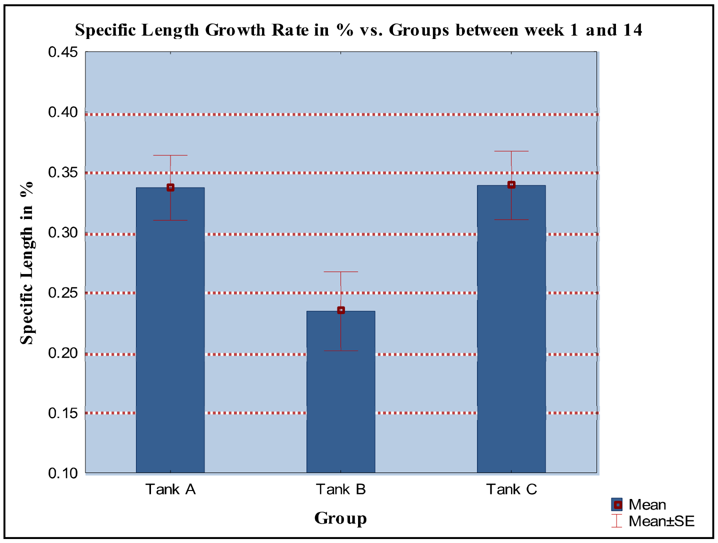
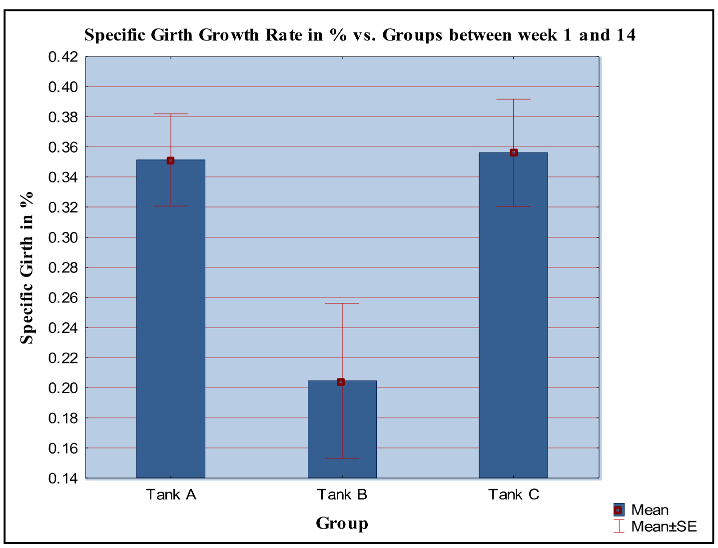


Figure 26a

	Tank A	Tank B	Tank C
Tank A		0.052841	0.998794
Tank B	0.052841		**0.047636**
Tank C	0.998794	**0.047636**	

Figure 26b



	Tank A	Tank B	Tank C
Tank A		**0.040154**	0.996293
Tank B	**0.040154**		**0.033416**
Tank C	0.996293	**0.033416**	

Figure 27a

Figure 27b

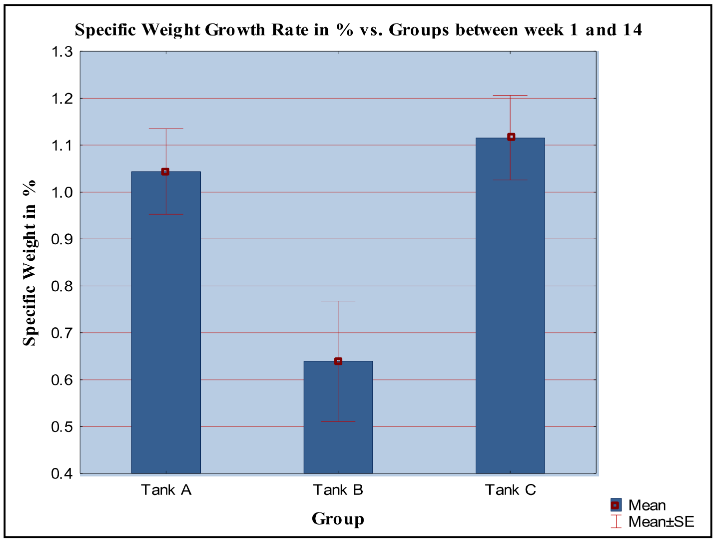


Figure 28a

	Tank A	Tank B	Tank C
Tank A		**0.028689**	0.879092
Tank B	**0.028689**		**0.009192**
Tank C	0.879092	**0.009192**	

Figure 28b

When the data from the first week and the last week were compared, significant differences in specific length, girth and weight were noted as depicted in the above graphs.

A significant difference in specific length (p= 0.047636) could be seen between Tank B and Tank C. In specific girth, significant differences could be seen between Tank A and Tank B (p= 0.040154) and also between tank B and Tank C (p= 0.033416). When specific weight statistical analysis was carried out, differences between Tank A and Tank B (p= 0.028689) and between Tank B and Tank C (p= 0.009192) were noted.

The three graphs below show the statistical variance based on the comparison of the data collected on week1 and week 2. The specific length, girth and weight versus the group are shown and the statistical p-values are shown next to each corresponding graph.

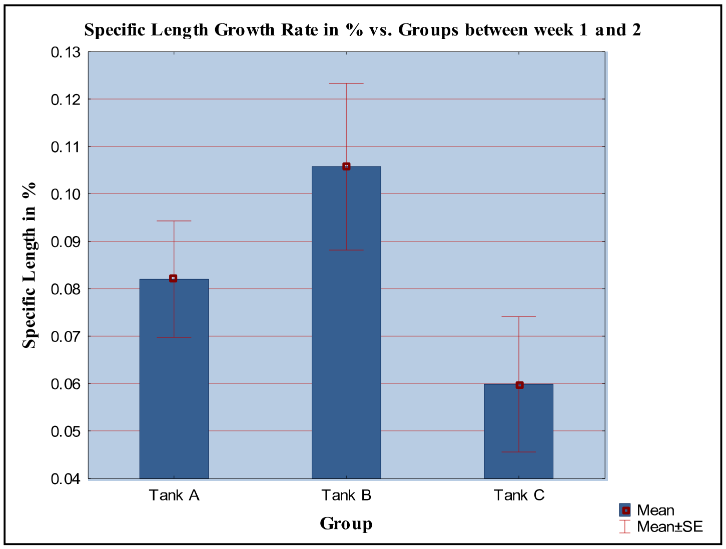


Figure 29a

	Tank A	Tank B	Tank C
Tank A		0.505883	0.550290
Tank B	0.505883		0.092749
Tank C	0.550290	0.092749	

Figure 29b

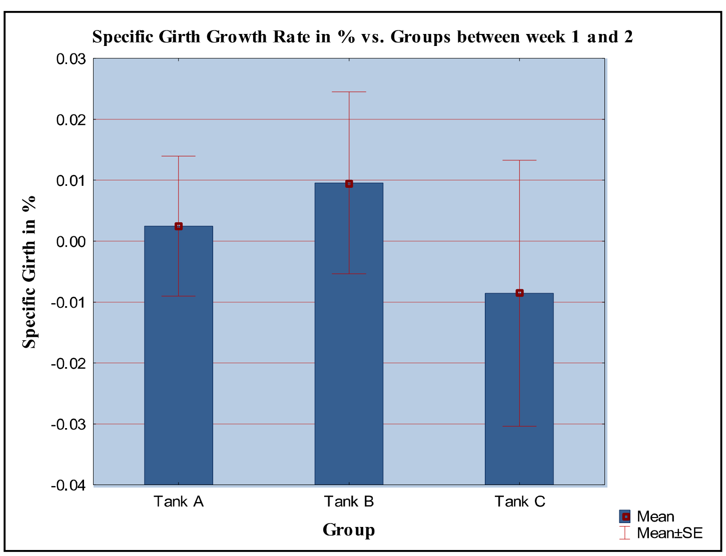
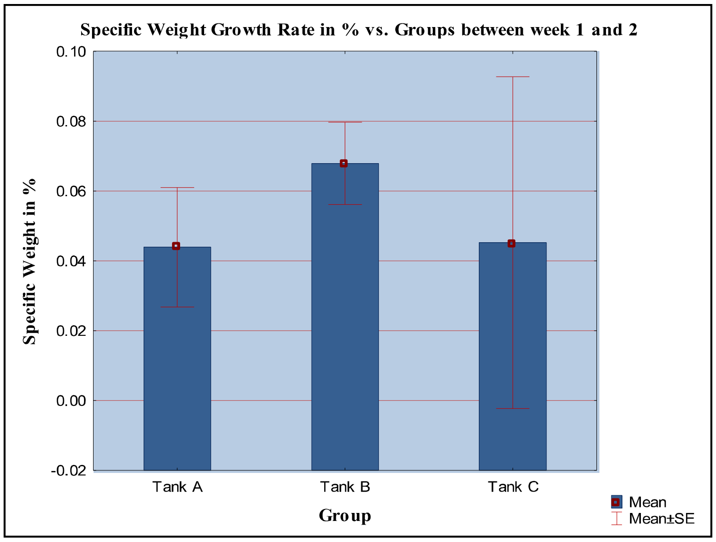


Figure 30a

	Tank A	Tank B	Tank C
Tank A		0.951126	0.886518
Tank B	0.951126		0.723884
Tank C	0.886518	0.723884	

Figure 30b



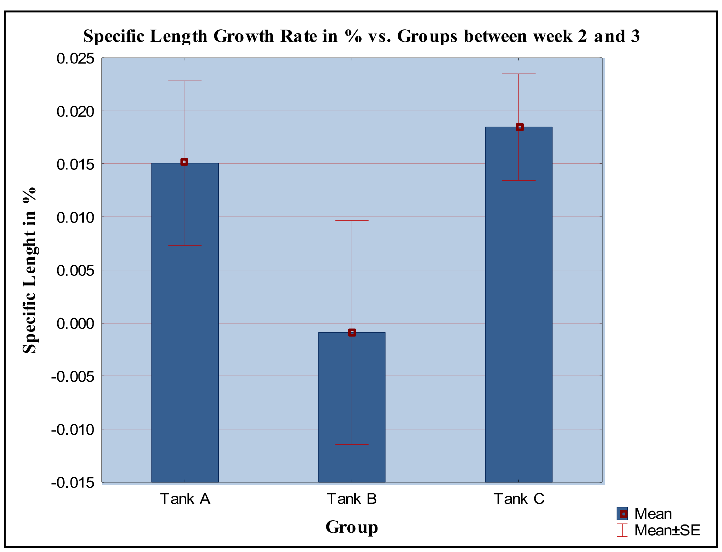
	Tank A	Tank B	Tank C
Tank A		0.838783	0.999545
Tank B	0.838783		0.854447
Tank C	0.999545	0.854447	

Figure 31a

Figure 31b

When the data from the first week and the second week were compared, no significant differences in specific length, girth and weight were noted, as shown in the graphs above. This shows that no significant differences could be shown at the experimental start up.

In the following three graphs the statistical variance based on the comparison of the data collected on week 2 and week 3 is shown. The specific length, girth and weight versus the group are shown and the statistical p-values are shown next to each corresponding graph.



	Tank A	Tank B	Tank C
Tank A		0.359102	0.952699
Tank B	0.359102		0.227700
Tank C	0.952699	0.227700	

Figure 32a

Figure 32b

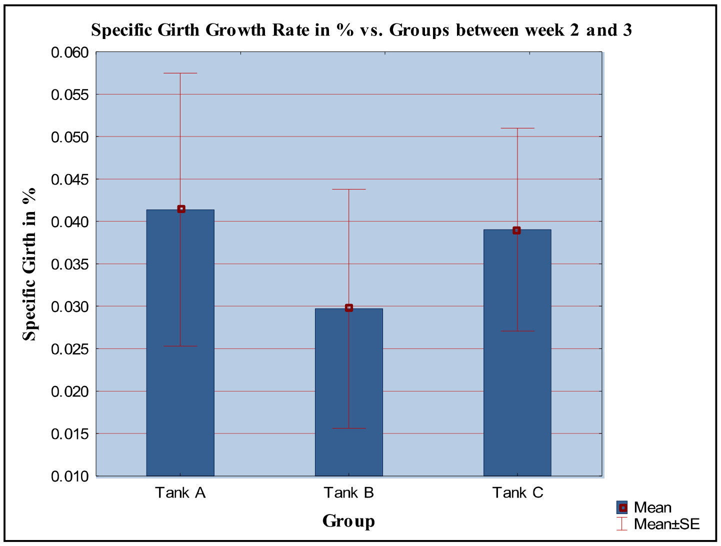


Figure 33.a

	Tank A	Tank B	Tank C
Tank A		0.830191	0.992522
Tank B	0.830191		0.887724
Tank C	0.992522	0.887724	

Figure 33b

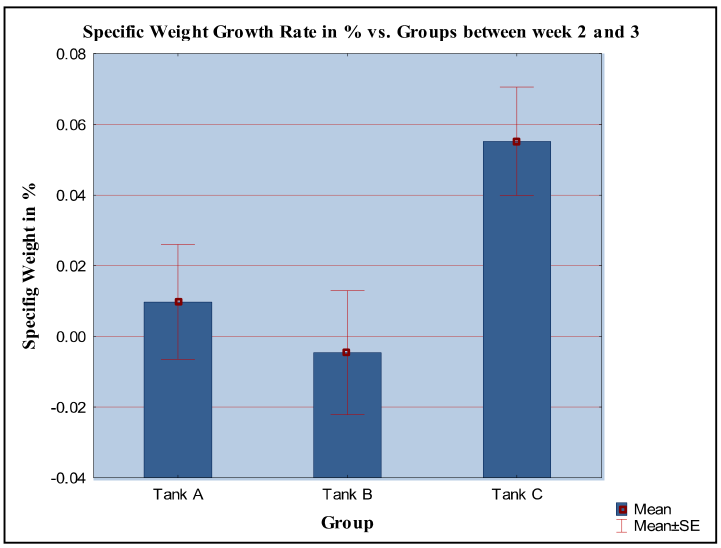


Figure 34a

	Tank A	Tank B	Tank C
Tank A		0.810877	0.142672
Tank B	0.810877		**0.040620**
Tank C	0.142672	**0.040620**	

Figure 34b

When the data from the second week and the third week were compared, no significant differences in specific length and girth were noted, as are shown in the graphs above. This shows that no significant differences in length and girth could be shown on the first week with musical stimulation. A significant difference in specific weight was noted between Tank B and Tank C (p= 0.040620). The significant difference in weight between the Mozart group and the control group might suggest that Mozart music on the juvenile Koi causes stress which resulted in less feed intake and shunted increase in weight.

Throughout the 14 week experiment the fish behaviour was observed. The fish in Tank A seemed to like the music. When the music was turned on, the fish would gather in a corner opposite to the speaker and sometimes swim fast around the tank and go back 'listening' to the music. In tank B the fish would also gather around but they seemed to be less active and stayed in one place. The fish in tank C swam around the tank all day long and seemed quite active. The same activity was noted in tanks A and B when no music was played.

An interesting observation was noticed in two particular periods. Between week 7 and week 8 a decreased interest in feed intake was observed and a decreased growth rate was reflected on the graphs in all 3 tanks. During this week the time was turned one hour forward. This daylight saving time change has affected their feeding pattern which resulted in less feed intake and a decreased growth rate as shown in the graphs below.

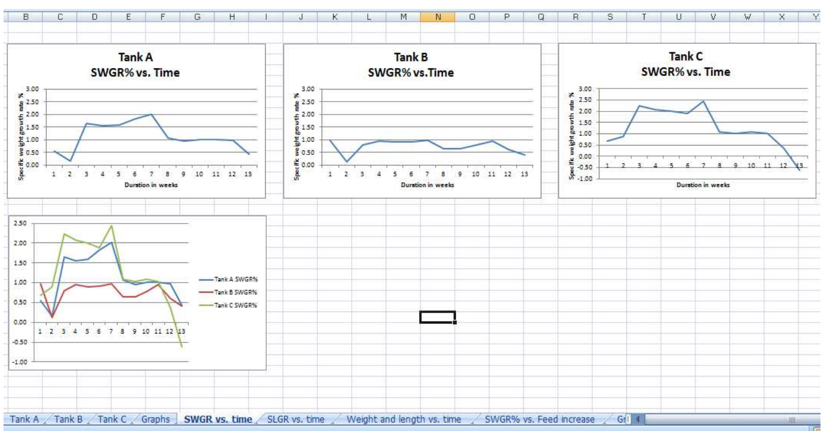


Figure 35

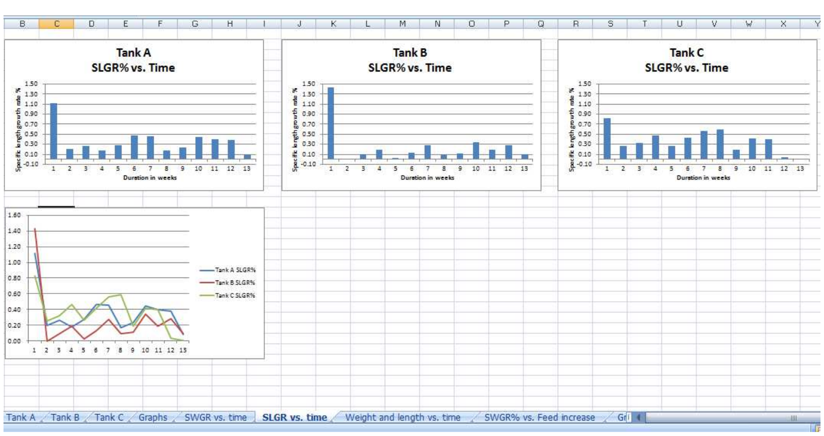


Figure 36

Another period, which shows a decreased growth rate is between week 13 and week 14. At the end of week 13, a partial water change was carried out which might have stressed the fish and resulted in a decreased growth rate.

The weekly observation and data collected showed that the fish in tank B grew much slower than the fish in the other tanks suggesting that the fish were stressed. The fish in tank C (Control) grew evenly unlike the fish in tank A (chill-out), in which some fish grew bigger than others which might suggest that some fish liked the music while others liked it less.

According to the statistical analysis a significant difference in specific length ($p = 0.047636$) could be seen between Tank B (Mozart) and Tank C, showing that Mozart music did not increase the growth rate but rather shunted it. In specific girth, significant differences could be seen between Tank A and Tank B ($p= 0.040154$) and also between tank B and Tank C ($p= 0.033416$. When specific weight statistical analysis was carried out, differences between Tank A and Tank B ($p = 0.028689$) and between Tank B and Tank C ($p= 0.009192$) were noted, which might be due to the stressful stimuli which resulted in less feed intake and therefore shunted growth

EVALUATION OF THE DATA

According to VASANTHA et al. (2003) in their study on the influence of music on the growth of Koi carp, the fish subjected to Mozart music showed a significantly higher growth rate than the control group. In my study on the other hand, the fish subjected to 'Eine kleine Nachtmusik' by Mozart showed the slowest growth rates, while the control group showed even growth among the fish and also the highest growth rates. The growth rates in tank A - the fish subjected to chillout music, were surprisingly interesting as the growth rates were very similar to the ones recorded in the control tank. Although it seems that music does have an effect on the growth rate of fish, whether the result is a positive or a negative one, more studies and experiments need to be carried out to verify the hypothesis, and find the appropriate background musical genre. At the end of the week 14 of the experiment, besides the growth rate, we also wanted to check whether the body composition would differ between these three groups. An analysis of both the feed and that of the fishes' total body composition was carried out by *Emese Andrásofszky* and her co-worker (**Table 1**).

Table 1. Approximate chemical composition of the koi feed and the fish bodies (as matter basis)

Parameter	Koi Royal Large	Chill-out	Mozart	Control
Water, %	6.53	69.6	71.9	68.2
Ash, %	5.33	1.81	2.07	1.65
Ether extract, %	5.08	13.4	11.4	16.3
Crude Protein, %	32.4	13.6	13.3	12.7
Crude fibre, %	1.90	-	-	-

The results of the total body composition (pooled sample /treatment, no statistical evaluation) as seen above indicate that the fish subjected to music by Mozart have intermediary high **protei**n content(13.3%), compared to the higher (13.6%) chill-out and 12.7% control). The **fat (syn. ether extract)** concentration is higher in the fish subjected to chill-out music (13.4 vs. 11.4%, compared to Mozart), but lower than the control group (16.3%). The fish subjected to chill-out music have intermediary fat content and slight higher protein content than the fish in tank B. The control group has the lowest protein content (12.7%) and the highest fat concentration (12.7%). This result seems interesting as people are nowadays becoming more aware of their health. More research needs to be carried out to verify this finding. The koi-fish in the control group had the highest dry matter content (31.8%), the Mozart-exposed the lowest (28.1%) and the chill-out music group is intermediary (30.4%) (**Table 1**).

The body chemical composition analysis carried out by PAPOUTSOGLOU et al. (2010) did not differ among experimental treatments.

The above results regarding growth rates of fish subjected to music as well as body composition analysis seem to be contradictory. The number of experiments in this field is limited and therefore it is difficult to prove the hypothesis. More research needs to be carried out, especially to find the best type of music.

CONCLUDING REMARKS

With scarce data about the effect on Koi fish subjected to music and my personal interest in these ornamental fish, I carried out this experiment to have my own data to compare with the similar experiments done. Having my own results gave me a closer insight of the fish behavior and their reaction to music with respect to growth rates and body composition.

With four hypothetical theories to commence this study, there is no answer for each one. **Table 2** summarises the absolute (ΔW, grams) and specific (true) weight (SWGR, %) and the absolute length growth ***(ΔL, cm), and the specific length growth rate (SLGR, %)*** between week 1 and 14.

Table 2. Absolute and specific weight and length growth between week 1 and 14

Group/Parameters	**ΔW, grams**	**SWGR, %**	**ΔL, cm**	**SLGR, %**
Chill-out	5.61	0.54	8.0	1.11
Mozart	1.59	0.15	1.5	0.20
Control	18.63	1.65	2.0	0.26

Based on the statistical analysis carried out, one can state that ***when comparing the first and the last week a significant difference in specific length (p = 0.047636) could be seen between Tank B (Mozart) and Tank C (Control). In specific girth measure, significant differences could be seen between Tank A (Chill-out) and Tank B (p= 0.040154) and also between tank B and Tank C (p= 0.033416). With respect to specific weight results, differences between Tank A (Chill-out) and Tank B (p= 0.028689) and between Tank B and Tank C (p= 0.009192) were noted.*** This result clearly shows that the difference did not happen by chance but music stimulation was the parameter responsible for such differences. Therefore from my results I can say that classical music had a negative impact on the growth rate and chill out music had a neutral or positive effect on the growth rate of Koi fish.

It is more informative, if expressing chemical values of the total body composition, in the dry matter (**Table 3**). Thus, the chill-out music exposed koi-fish grows faster and get heavier, larger and longer, than the music-free control, or the Mozart group. ***Chill-out fishes have the lowest fat percent in dry matter (82% that of the control), and intermediary protein level (111% of the control). The highest protein concentration (119% of the control) can be found in the body of the Mozart group, their fat level is also low (89% of the control).*** They have a relatively high ash content (142% of the control), which may reflect a highly developed skeletal system.

Table 3. Total body composition of the Koi fishes

Parameter	Chill-out	Mozart	Control
Water, % of total body	*69.6*	*71.9*	*68.2*
Ash, % of DM	6.0	7.4	5.2
Ash, % of control	*115*	*142*	*100*
Fat, % of DM	44.1	40.6	51.3
Fat, % of control	**82**	89	100
Protein, % of DM	44.7	47.3	39.9
Protein, % of control	*111*	***119***	*100*

The behaviour of the three groups was dramatically different: the Mozart group moved much more time during the whole experiment. As a conclusion, the koi reacted to the music with behavioural changes, modified growth and body composition. The choice of background music should depend on the purpose of the operation. In a laboratory facility, under the umbrella of the 3 “R”s, especially the Refinement and Environmental Enrichment, the more vigilant, natural behaviour may be more preferable. On the contrary, in a commercial, food producing fish farm the chill-out music seems to be advantageous.

After having reviewed the literature, completed this experiment and studied the results, I am afraid to say that the data about the effect of music on Koi fish is contradictory, or rather, the choice of music genre should depend upon the keeping-production purposes.

More research needs to be done to find out whether music, if used as an environmental enrichment, could really influence the growth rate and body composition of these fish. The genre, the frequency and the volume used are also important parameters, which need to be further studied. A positive result in this field could result in practical use for better fish welfare as well as in the aquaculture industry for shorter raising periods and leaner and healthier meat.

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Apart from the efforts done by myself, the success of any project depends largely on the encouragement and guidelines of many others. I would never have been able to finish my thesis experiment and writing without the guidance of my tutor, help from friends, and support from my family members and girlfriend.

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SUMMARY **Brincat, Daniele: THE INFLUENCE OF DIFFERENT MUSICAL STIMULATION ON THE GROWTH RATE OF KOI CARP (*Cyprinus carpio*)**

The aim of my study was to verify if classical music really enhances the growth rate in Koi carp as shown in the study performed by by VASANTHA et al. (2003). We also wanted to verify if, classical music or music in general enhances growth rate of Koi carp, therefore I included a 3rd group with chill out music to compare results.

A fourteen-week-long experiment was carried out to investigate whether music does influence the growth rates of Koi Carp (*Cyprinus carpio*). Three tanks were set up with ten fish in each tank; Tank A, Tank B, Tank C. Each tank was set up to have same water volume, water filtration, light period, feed percentage intake and temperatures. Tank A contained chill out music – *'Deep House Mix'* by TREVOR NYGAARD, Tank B contained classical music – *'Eine kleine Nachtmusik'* by WOLFGANG AMADEUS MOZART, while Tank C was used as a control and contained no music. Weekly growth in weight, length and girth was measured and recorded and used to calculate the weekly gain, the growth rate and specific growth rates of weight, length and girth. The difference in growth between each group of fish was statistically tested for significance.

During the whole experiment the Mozart-fishes moved more, than the two other groups.

Results show, when comparing the first and the last week a significant difference ($p < 0.05$) in specific length could be seen between Mozart and Control group. In specific girth measure, significant differences could be seen between Chill-out and Mozart fishes and also between Mozart and Control group. With respect to specific weight results, differences between Chill-out and Mozart and between Mozart and Control group were noted. In all cases, the Mozart –fishes were smaller and lighter, than the two other groups.

Chill-out fishes have the lowest fat percent in dry matter (82% that of the control), and intermediary protein level (111% of the control). The highest protein concentration (119% of the control) can be found in the body of the Mozart group, their fat level is also low (89% of the control).

ÖSSSZEFOGLALÁS, BRINCAT, DANIELE: KÜLÖNBÖZŐ ZENÉK HATÁSA A KOI-PONTYOK (*Cyprinus carpio*) NÖVEKEDÉSÉRE

Jelen vizsgálat célkitűzése az volt, hogy tisztázuk, vajon a klasszikus zene valóban serkenti-ea koi-pontyok fejlődését, mint az VASANTHA és mtsai (2003) munkájában olvasható, illetve. hogy zene sugárzása egyáltalán, hat-e a koi-ponty növekedésére. Azutóbbi eldöntésére egy modern zeneiingernek (chill-out music) kitett pozitív kontrollcsoportot is beállítottunk. A vizsgálat 14 hétig tartott. Három hő- tankot állítottunk be, A tankok azonos méretűek voltak, s a víz azonos mennyiségét, szűrését, fényperiódusát, hőmérsékletét, a takarmány kiadagolását laptop vezérléssel biztosítottuk. Az A-jelű tankban – vízalatti hangszórók segítségével TREVOR NYGARD *"Deep House Mix"* CD-jét, a B-tankban WOLFGANG AMADEUS MOZART '*Egy kis éjizené*'-jét sugároztuk. A C-tank pontyjai nem kaptak külön zenei ingert. A halaknak hetente egyedileg lemértük az élősúlyát, hosszát és testkörméretét, s kiszámítottuk a heti súlygyarapodást, a napi átlagos súlygyarapodást és az ún. valódi (pillanyatnyi) növekedési rátát, (BRODY, 1945). A halakat külsőjegyeik alapján azonosítani lehetett. A fölvett adatokat hetente és a kísérlet teljes időtartamára varianciaanalíznek és szignifikanciaszámításnak vetettük alá. A kísérlet lezárásakor euthanasiának alávett halaknak csoportonként meghatároztuk a teljes testösszetételét.

A vizsgálat teljes időtartama alatt a Mozart-csoport halai lényegesen elevenebbek voltak, többet mozogtak, mind a másik két csoport egyedei.

Az első és utolsó hét adatait hasonlítva össze, szignifikáns különbségeket ($p < 0.05$) találtunk a specifikus hosszban a Mozart- és kontrollcsoport között. A specifikus testkörméret is a Mozart-zenét hallgató csoportban volt a legkisebb. A 'pillanatnyi növekedési ütem' tekintetében a kontrolcsoport volt a legjobb (1.65), a chill-out közepes (0.54) és a Mozart-halaké a legkisebb (0.15). A 'pillanatnyi hossznövekedélsben' viszont a Chill-out halak a legjobbak (1.11), majd a kontrollhalak következnek (0.26), s e mutató tekintetében is legutolsó a Mozart-csoport (0.20).

A chill-out halaknak a legkisebb a szárazanyagban mért zsírtartalma (82% that of the control), and intermediary protein level (a kontroll 111%-a). a legnagyobb fehérjekoncentráció viszont a Mozart-halak testében volt (a kontroll 111%-a), de zsírtartalmuk is kics (a kontroll 89%-a).

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