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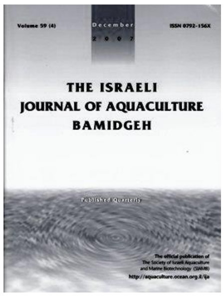

The Effect of Different Tempos of Music During Feeding, on Growth Performance, Chemical Body Composition, and Feed Utilization of Turbot (*Psetta maeotica,* Pallas 1814).

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Key words: Turbot, music, tempo, growth performance, feed utilization, body chemical composition

Abstract

The effects of different tempos of music on growth, body chemical composition and feeding parameters of turbot (*Psetta maeotica*, Pallas 1814) were investigated. Turbot (average weight 160.61±1.53 g) were reared in a circulating sea water system for 8 weeks with music playing for 5 hours at each feeding. The music treatments consisted of slow tempo music (adagio; metronome speed 66-76), medium tempo music (moderate; metronome speed 108-120), fast tempo music (allegro; metronome speed 120-168) and control group (no music). Results demonstated that the fast tempo music treatment (FTM, p<0.01) had a negative effect on fish growth, but when slow tempo music (STM) was transmitted, growth improved slightly. Best growth performance was observed when the fish were exposed to slow tempo music. The FTM group showed signs of stress and reduced feed intake. Music transmission significantly affected carcass fat content (p<0.05). No significant effect was observed on protein, ash or moisture content.

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Introduction

The sedative effect of music on human psychology and behaviour is known (Snyder and Chlan, 1999). The effect of the sounds of music on animals raised under human control and in stressful environments has also been investigated. Red deer displayed much more aggressive behaviour when loud music was played, and more attentive behaviour when music ceased, compared to deer not exposed to music (Hodgetts et al. (1988). When music was played to cows they accepted the automatic milking machines more willingly (Uetake et al., 1997). Music reduces stress and stimulates growth in chicks (Gvaryahu et al. 1989). However, music or other sounds had no effect whatsoever in piglets during their handling and weaning (Cloutier et al 2000). Both specific noise (90 dB versus 65 dB) and classical music (75 dB versus 65 dB) induced stress and fear in laying hens (Campo et al., 2005).

Biologically, fish are able to detect source and direction of sounds and can also produce various response sounds (Fay, 1998; Popper et al., 2003). Some species are able to hear sounds above 180 kHz. Studies regarding the effects of anthropogenic sounds on marine mammals are attracting attention. Anthropogenic sounds have been shown to affect fish, turtles, aquatic birds, and even water invertebrates (NRC 1994, 2000, 2003; Richardson et al., 1995). Studies regarding the effect of noise on cultured fish are considerably limited and this subject needs to be researched in the future. Previous studies on the effect of sound were conducted primarily on anthropogenic noise from ships and fishing vessels, seismic air guns, sonar, as well as machinery in aquaculture facilities (Bart et al., 2001; Popper, 2003).

Music affects fish in terms of decreasing stress in aquacultural environments and promoting growth (Papoutsoglou et al, 2008; Papoutsoglou et al., 2007). The auditory sense of fish is based on a complex structure consisting of lateral lines, swimbladder, and otoliths (Fay and Popper, 2000; Popper et al., 2003). While most fish can detect sounds at frequencies up to 1000 Hz (e.g. *Oreochromis niloticus* L., *Ammodytes personatus* R; Fay et al., 2000; Popper et al., 2003), some fish are able to hear up to 3000-4000 Hz, with the help of special adaptations (*Ictalurus punctatus* R., *Carassius auratus* L., *Cyprinus carpio* L; Fay et al., 2000; Popper et al., 2003). *Alosa sapidissima* (Wilson) with more specialized hearing adaptation can hear ultra sound frequencies above 180 kHz (Fay et al., 2000; Popper et al., 2003).

Koi (*Cyprinus carpio*) can distinguish between blues and classical music (Chase, 2001) and growth rates of koi exposed to violin music (the raga Nalinakanthi) were greater than the control (Vasantha et al., 2003). The effect of music by Mozart (andante) on carp under different light conditions has also been studied (Papoutsoglou et al., 2007). Results of these studies revealed that music may be a factor in diminishing or even abating stress. They suggested that stress abating music could improve fish health in intensive aquaculture enterprises and that music had the potential to increase product quality and growth. However, music in the rearing environment was found to have no positive or negative effect on goldfish growth (Imanpoor et al., 2011).

The aim of this study was to determine whether different tempos of music have an effect upon turbot feeding thereby affecting growth performance and biochemical composition.

Materials and Methods

The experiment was conducted at a private aquaculture farm, Mugla (Turkey). One hundred and thirty two turbot (*Psetta maeotica*, Pallas, 1814) were acclimatized to water temperature in tanks for 7 days. Thereafter, 11 fish with an average body weight of 160.61±1.53 g were randomly distributed to each of 12, 500 L fiberglass tanks supplied with a continuous flow of seawater at 4.0 L/min. During the experiment, mean water temperature, oxygen and salinity levels were monitored at 20.13±1.13 °C, 7.3± 0.3 ppm and 25.3±5.2 ppt, respectively. Triplicate groups of these fish were fed the same commercial diet (crude protein, 50.8%; crude lipid, 13.53%; moisture, 5.99%; ash 11.97%) by hand to satiation twice a day, at 08.00 and 16.00 h.

Fish were exposed to the different tempo treatments using a DVD player and loudspeakers (with a sound capacity of 20-30 watt power and 30-120 dB intensity). The loudspeakers were wrapped in plastic algae bags to prevent water damage and there was a speaker placed in each tank. Each tempo treatment was begun automatically, beginning thirty minutes before each feeding and continuing for 5 hours.

The tempo range tested was approximately 40-200 beats-per-minute. The most common tempos from slowest to fastest are largo (40-60 BPM), larghetto (60-66 BPM), adagio (66-76 BPM), andante (76-108 BPM), moderato (108-120 BPM), allegro (120-168 BPM), presto (168-200 BPM) and prestissimo (200-208 BPM) (Harnum, 2001).

The five music treatments used were; slow tempo music 'STM' (adagio; metronome speed 66-76 Bpm), medium tempo music 'MTM' (moderate; metronome speed 108-120 Bpm), fast tempo music 'FTM' (allegro; metronome speed 120-168 Bpm), and control (no music).

The STM treatment was exposed to 47 pieces of music (adagio; metronome speed 66-76); the MTM treatment to 59 pieces, and the HTM treatment to 24 pieces. No music was played to the control group.

The tanks were covered with canopies which were opened just enough to observe the fish consume the feed. Feeding was conducted carefully in order not to frighten the fish. Feeding continued until satiation, which was determined when fish remained motionless at the bottom of the tank and ceased eating. The number of pellets eaten to reach satiation was counted. When feeding ceased, the tank bottom was cleared by siphoning all surplus food scraps and feces. In each tank, the water flow rate was 4.0 L/min. Water and air inlets were separate for each tank. Water was injected into the tanks through a submerged hose. Oxygen stones were submerged and placed next to the water inlets.

During the trial, the fish were individually weighed every 2 weeks. All fish were harvested at the end of the trial period, counted, and weighed individually. Fish growth and feed utilization were calculated as follows:

Relative growth rate %= 100 × (Wf − Wi)/(Wi),

Specific growth rate= [(ln WF-ln WI) x 100/days],

Feed efficiency= (wet weight gain x 100/dry weight feed offered),

Weight gain= (wet weight gain x 100/initial weight),

Total protein intake= (total feed intake × protein content of feed)/100,

N content in fish= (body protein / 6.25),

apparent net protein retention = [(final weight in g x final body protein in %) - (Initial weight in g x Initial body protein in %) / protein intake in g] x 100.

Twelve fish from the initial stock population prior to the commencement of the trial, and three fish from each experimental group at the conclusion of the trial, were randomly sampled and stored at -20°C for subsequent body carcass composition analysis. Body carcass biochemical composition was analyzed for dry matter, crude protein =(N × 6.25), crude fat and crude ash contents according to the methods of AOAC (1995).

Statistical analysis included one-way analysis of variance (ANOVA) and Tukey's multiple significant difference tests using the software program Minitab 13 for windows. Differences were regarded as significant at p=0.05.

Results

No fish died during the experiment. Depending on the period, the highest average fish weight was reached in the STM group.

In the experiment, relative growth rate and specific growth rate were highest in the STM group and significantly higher than in the FTM group (Table 1).

Table 1. Growth performance of turbot exposed to different tempos music for 8 weeks

	Initial mean weight (g)	*Final mean weight (g)*	*Relative growth rate (%)*	*Specific growth rate (%)*
Control	159.48 ± 2.30	215.60 ± 7.06^{ab}	35.17 ± 0.80^{ab}	0.54 ± 0.01^{ab}
STM	159.39 ± 1.38	238.03 ± 4.05^{b}	49.29 ± 3.24^{b}	0.71 ± 0.04^{b}
MTM	161.66 ± 1,52	231.52 ± 8.87^{ab}	43.16 ± 4.72^{b}	0.64 ± 0.06^{b}
FTM	161.91 ± 1,58	205.60 ± 5.48^{a}	26.99 ± 3.29^{a}	0.43 ± 0.05^{a}

Values (mean±SEM) in the same column with different superscripts are significantly different (p<0.05).

Feed intake and weight gain were lower in the FTM group. As the tempo of the music increased, feed intake of the fish showed a significant decrease ($p<0.05$). With regard to feed efficiency, N content in fish (%) and ANPR (%) values, no statistically significant difference between the four groups was observed ($p>0.05$). However, the highest values for total protein intake (g) were obtained from the STM group ($p<0.05$). Feed intake was higher in fish in the STM group, while feed intake and other feeding parameters of the FTM group were slightly negatively affected (Table 2).

Table 2. Effect of different music tempos on feed intake, feed efficiency, total protein intake, N content in fish, apparent net protein retention (mean ±S.E., n=3).

Group	*Feed intake (g/tank)*	*Feed efficiency (%)*	*Total protein intake (g)*	*N content in fish (%)*	*ANPR (%)*
Control	948.33 ± 11.83^{b}	0.65 ± 0.02^{a}	481.75± 6.01^{b}	3.12 ± 0.04^{a}	28.54± 0.36^{a}
STM	1029.67 ± 12.00^{c}	0.84 ± 0.06^{a}	523.07 ± 6.10^{c}	3.14 ± 0.03^{a}	36.20± 2.25^{a}
MTM	938.33 ± 8.41^{b}	0.82 ± 0.10^{a}	476.67± 4.27^{b}	3.03 ± 0.05^{a}	32.45± 4.54^{a}
FTM	547.00 ± 10.05^{a}	0.88 ± 0.09^{a}	277.88± 5.11^{a}	3.01 ± 0.05^{a}	34.77± 3.65^{a}

Values (mean±SEM) in the same column with different superscripts are significantly different ($p<0.05$).

Results of chemical analysis performed on the carcasses at the beginning and at the end of the experiment (Table 3), showed no significant differences between the groups in terms of crude protein content at the end of the experiment ($p>0.05$). At the end of the experiment, the lowest crude ash content measurements were obtained in the STM group. While no statistical differences were observed between the control group and MTM and FTM groups, the differences among the STM, control, and FTM groups were statistically significant ($p<0.05$).

Table 3. Proximate body composition (% wet weight) of turbot exposed to different music tempos for 8 weeks (n=3) .

Groups	*Moisture (%)*	*Protein (%)*	*Fat (%)*	*Ash (%)*
Initial	74.47 ± 0.3	18.48± 0.4	5.8 ± 0.1	1.25 ± 0.2
Final				
Control	72.57 ± 0.1^{a}	19.48 ± 0.20^{a}	6.6 ± 0.07^{a}	1.26 ± 0.01^{a}
STM	71.42± 0.4^{a}	19.61 ± 0.16^{a}	7.6 ± 0.2^{b}	1.22 ± 0.01^{b}
MTM	72.57±0.7^{a}	18.95 ± 0.18^{a}	7.1 ± 0.2^{ab}	1.28 ± 0.02^{ab}
FTM	72.44±0.5^{a}	18.84 ± 0.28^{a}	7.0 ± 0.1^{ab}	1.34 ± 0.02^{a}

Values (mean±SEM) in the same column with different superscripts are significantly different ($p<0.05$).

Discussion

Since the number of studies regarding the effect of music on growth, feed intake, and body biochemical composition of fish is limited, it is difficult to discuss this study and make comparisons. The only studies regarding the effect of music found in the literature are the effect of music (adagio) on the growth of Koi fish (Vasantha et al., 2003), and the effects of Mozart's music (andante) on stimulation of the physiology of common carp (Papoutsoglou et al., 2007; Papoutsoglou et al., 2008).

Equipment such as aerators, air and water pumps, and filtration systems occasionally used in intensive aquaculture unavoidably increase the noise level in fish culture tanks (Davidson et al., 2009). As a result of being exposed to noise, the species being reared may be affected negatively (Wysocki et al., 2007). On the other hand, the transmission of music creates a calming, antidepressant effect on most species (human beings, mammals, birds etc.). Music may also play a role in relieving or inducing stress (Papoutsoglou et al., 2007). Music was found to increase growth performance, feed intake and welfare of fish (Papoutsoglou et al., 2008).

In this study, the STM affected the feeding behaviour of turbot (*Psetta maeotica)*, and improved growth rates and biochemical composition of the fish. While the fish in the STM group showed increased feed intake, the fish in the FTM group demonstrated stressful swimming behavior and loss of appetite. Growth increased when slow tempo music was played to turbot (*Psetta maeotica*). These effects on growth were similar to those previously reported (Papoutsoglou et al., 2008). In contrast, there was no effect of ongoing exposure to loud production noise on the growth or mortality of rainbow trout

(Wysocki et al. 2007). Reduced egg viability and reduced growth rates of two cyprinodontiform fishes were observed when sound pressure levels (SPL) were approximately 20 dB higher than levels in the control tanks (Banner and Hyatt,1973).

Chronic elevation of in-tank noise levels (about 30 dB higher than levels encountered in their natural habitat) resulted in significant reduction in growth, reduced food consumption, and lower reproduction rates (Lagardère 1982). Another study investigating effects of noise on seahorses revealed that weight of the group exposed to noise was negatively affected (Anderson et al., 2011). This study demonstrated that FTM has a significantly negative effect on the relative growth rate of fish. In their studies on the effect of Mozart's music (andante) on the physiology of carp, Papoutsoglou et al. (2007) revealed that exposing fish to music for 30 minutes improved the growth of the fish and emphasized that fish presenting reduced growth exhibited significantly increased brain neurotransmitter levels, indicating a stress response. In another study, the music of Mozart and Romanza (andante) increased the specific growth rate of carp (Papoutsoglou et al., 2010).

Neurobiological evidence from human and comparative animal studies, confirms that musical stimuli modify autonomic and neurochemical arousal indices, and may also modify synaptic plasticity (Rickard et al., 2005). When carp were exposed to Mozart for 30 minutes the serotonin level (5 HT) was lower compared to the control group and the group exposed to Mozart for 60 minutes (Papoutsoglou et al., 2007). In a study on goldfish, it was determined that 2 hours after serotonin (ICV 5-HT) injection, feed intake decreased approximately 94% (de Pedro et al., 1998). Daily feed consumption increased in the groups exposed to music by Mozart and Romanza (Papoutsoglou et al., 2010). In contrast, in a study on gilthead sea bream, exposure to light (80 lx; 200 lx) and music (0, 2, 4 hours) had no statistically significant effect on their feed intake (Papoutsoglou et al., 2008). The results of this study showed a poor FCR value for turbot exposed to FTM music. FCR for Mozart-treated fish was not significantly different from that of the control, or Romanza-treated fish (Papoutsoglou et al., 2010). The variability of the FCR values obtained in the studies could be related to media properties, species, fish size, trial period, noise level, sound frequency, and music genre. In this study, due to exposure to high intensity music, feed intake of the fish decreased, and consequently their growth was slow.

When the biochemistry of turbot was examined, treatments did not have an effect on protein content ($p>0.05$). Relatively high fat content was measured in the STM group. Ash content was lowest for the STM group. This group was also the group with the best growth rate. These results are similar to low ash content measured by Papoutsoglou et al.(2010) for carp exposed to music by Mozart and Romanza (andante). In another study which investigated the effect of Mozart on carp in different environments and periods, no difference was found between protein, fat, and ash content in the flesh of fish (Papoutsoglou et al., 2007).

Conclusions

Music has been shown to have a stress-reducing effect on fish in aquaculture. The genre, intensity, and application period of the music to which the fish are exposed, as well as the fish species, are important factors. In this study, it can be concluded that slow tempo music (adagio; metronome speed 66-76) increased growth and feed efficiency of turbot. We strongly suggest that further research be conducted on this subject using different tempos of music at different aquaculture facilities, and on more fish species at different stages of their life cycles, in order to close the knowledge gaps in this interesting and important field of research.

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