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DAILY BEHAVIOR OF RED TILAPIA (*Oreochromis niloticus*) CULTIVATED IN DIFFERENT AERATION AND FILTRATION

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ABSTRACT

Decreased water quality in red tilapia (Oreochromis niloticus) aquaculture indicates that low dissolved oxygen availability will affect fish behavior. One of the efforts to improve water quality is through the addition of aerators and filters. Aerators and filters increase the supply of dissolved oxygen and minimize feed waste in the aquaculture pond water. This study aims to analyze of different aeration and filtration or a combination of the daily behavior patterns of tilapia including eating behavior, aggressive behavior. The study was conducted for 1 month.This study used 24 red tilapia with a length of about 8-12 cm. The research design used in this study was a completely randomized design (CRD) with 4 experimental groups and 6 replications. The experimentals were ANF group (use of single aerator without filter), AANF group (use of dual aerator without filter), AF group (use of single aerator with filter), and group AAF (use of dual aerator with filter). The data collected includes the daily behavior of red tilapia and water quality. Analysis of the daily eating, aggressive and comfortable behavior of red tilapia was carried out by observing video recordings and recording behavior recording techniques at intervals of 1-2 minutes based on duration and frequency. The results showed that the use of different aerators and filters or their combination had a significantly different effect ($P<0,05$) on the daily behavior of red tilapia. The conclusion of this study was the raising used of multiple aerators and filters can improve the quality of aquaculture water so that it has a positive impact on feeding, foraging, and schooling behavior in the growth phase of tilapia.

INTRODUCTION

Red tilapia (*Oreochromis niloticus*) is one type of freshwater fish that has the potential to be developed in Indonesia (Sahetapy, 2013). The advantages of red tilapia cultivation are the low cost of cultivation, the fast growth rate of fish and good adaptability in various aquatic environments (Iskandar & Elrifadah, 2015). Red tilapia is known as a euryhaline fish, so it can live well in brackish and sea water with salinities ranging from 0-35 ppt. Tilapia habitat is fresh water, such as rivers, lakes, reservoirs and swamps (Yanti et al., 2013; Fadri et al., 2016).

The success rate of red tilapia cultivation is strongly influenced by the ability of farmers to manage water quality to achieve optimal growth (Putra et al., 2011). Dissolved oxygen is the main limiting factor in aquaculture systems that affect the behavior of fish in the water (Azhari, 2017). Fish behavior is described as the movement and response of fish stimuli to various stimuli in foraging for food in the water and competing as an effort to maintain the survival and stability of the body's physiology (Chairunnisa et al., 2018). Low dissolved oxygen levels will have an impact on decreasing fish appetite, so a lot of feed is not consumed by fish. Feed in aquaculture ponds also affects water quality. Metabolism and feed residues will decompose organic matter causing the formation of toxic compounds, such as nitrite, nitrate, and ammonia. This study aims to analyze the effect of different aeration and filtration experimentals or their combination on the daily behavior of red tilapia, which includes feeding behavior, aggressiveness, and fish comfort in aquaculture pond water.

MATERIALS AND METHODS

Place and time of research

The study was conducted for 5 months at the research house located at Jalan Parang Baris VII Number 18, Tlogosari Kulon, Semarang, Central Java, 50196.

Tools and materials

The tools used in this study were four plastic box containers with a capacity of 150 L (CB 150), a RESUN brand air pump aerator (LP20 type), Crown biofoam (58 type), Yamano brand filter (SP1000L type), pH meter (type PH-009(I)A), DO meter (type

DO9100), temperature and humidity meter type HTC-2, conductivity meter type WTW Cond 3210, spectrophotometer type DR3900, water volume measurement, cellphone (OPPO Reno 4F type), and tripods. The materials used in this study, i.e., research animals in the form of red tilapia, aquades, water, and commercial fish feed TAKARI brand size 2 mm.

Maintenance of Test Animals

Red tilapia was acclimatized for the first time for 14 days. The acclimatized fish were transferred to a rearing container filled with 40 liters of water. Each container contains 6 red tilapia as replication. Fish were fed 3 times a day with the ad satiation method in the morning, afternoon, and evening.

Data recording

Observations of the behavior of red tilapia were videoed in each container box twice per day in the morning (07.00-08.00 a.m) and afternoon (16.00-17.00 p.m) using a handphone camera for 10 minutes. Each behavior was observed for 1-2 minutes (60-120 seconds). The results of observations of the daily behavior patterns of red tilapia (feeding, foraging, schooling, resting, scratching, surfing, chasing, biting, and mouth pushing) per minute are calculated based on duration and frequency. The observed daily behavior of red tilapia is described in **Table 1**.

Table 1. Description of Recorded Behaviors

Behavioral patterns	Description
Eating behavior	
Foraging	The actual consumption of food at the time of feeding.
Feeding	The searching for food.
Comfort behavior	
Surficing	Fish are gulp air at water surface.
Scrathing	Rubbing of any part of body against any object (wall, floor and equipment of aquarium).
Resting	Fish are inactive and motionless with open eyes.
Schooling	Fish are swim or gather with each other.
Aggressive behavior	
Chasing (perburuan)	Fish swim vigorously to follow another fish.
Biting (menggigit)	Fish bits any part of body regions of another fish.
Mouth pushing	Fish were stand face to face with their opened mouth against each other's.

Water Quality Measurement

Measurement of environmental parameters was carried out twice a week during maintenance to determine the development of fish with measured habitat conditions, including dissolved oxygen, water temperature, water pH, salinity, and ammonia (nitrite and nitrate) using the DR3900 spectrophotometer. The water in the container will be drained and replaced with clean water as much as 70% of the total water if the water quality is below the specified limit. Tilapia rearing experimental was carried out for 30 days.

Research design

This research was conducted using a 2×2 factorial completely randomized design consisting of 4 experimental groups with 6 replications. The experimental factor was given to 24 tilapia according to the experimental groups specified in the rearing container. The experimental groups consisted of a single aerator without a filter (ANF), a double aerator without a filter (AANF), a single aerator with a filter (AF), and a double aerator with a filter (AAF). The research variables consisted of aerators and filters as independent variables and the behavior of feeding, foraging, schooling, resting, scratching, surfing, chasing, biting, and mouth pushing as the dependent variable.

Statistical analyses

Analysis of daily behavior patterns of eating, aggressiveness, and comfort of red tilapia was carried out by observing video recordings to be recorded with a behavioral recording technique for 10 minutes based on duration and frequency. The data on the daily behavior of red tilapia that has been obtained is then tabulated to be processed using the SPSS release 23 application to determine the distribution pattern and homogeneity. The results of the data analysis that showed a normal and homogeneous distribution pattern were then continued with further analysis with a two-way ANOVA test ($\alpha = 0.05$). Differences in each main factor and interaction test using the BNT test (Ramadan et al., 2018).

RESULTS AND DISCUSSION

The results of the analysis test using the Analysis of Variance (ANOVA) in Table 2 show that the use of aerators, filters or their combination has a significant effect (P<0.05) on feeding and foraging behavior in the morning and evening. The use of a double aerator equipped with a filter in this study could increase the feeding activity of fish, which was marked by a significant increase in the duration (Table 2 and the frequency of feeding or foraging behavior (Figure 2) red tilapia in the morning and evening.

Table 2. Duration of Red Tilapia Feeding and Foraging Behavior (Minutes/Group) in the Morning and Evening

Experimental groups		*Feeding*		*Foraging*	
		Morning	Evening	Morning	Evening
Aerator (A)	A	20,24^{a}±10,85	12,13^{a}±3,64	13,12^{a}±4,68	11,88^{a}±5,15
	AA	28,70^{b}±3,07	24,09^{b}±11,55	17,15^{b}±1,29	16,20^{b}±2,71
Filter (F)	NF	18,14^{a}±8,70	11,88^{a}±1,38	12,46^{a}±4,03	10,89^{a}±4,29
	F	30,80^{b}±1,79	24,34^{b}±11,75	17,81^{b}±0,79	17,19^{b}±2,02
Aerator x Filter	A x NF	9,94^{a}±1,36	10,71^{a}±0,96	8,66^{a}±0,55	7,08^{a}±1,44
	AA x NF	26,35^{b}±1,81	13,04^{b}±0,14	16,27^{b}±0,88	14,70^{b}±1,94
	A x F	30,55^{c}±1,62	13,55^{c}±4,84	17,58^{c}±0,48	16,67^{c}±1,14
	AA x F	31,06^{d}±2,06	35,14^{d}±0,98	18,05^{d}±1,01	17,70^{d}±2,65

a-dDifferent superscripts in the same column showed significantly different (P<0.05); The interaction effect between aerator and filter (aerator x filter) was significantly different (P<0.05). The data displayed is an average ± SD.

The use of dual aerators equipped with filters in this study can improve the quality of cultivated water, one of which is dissolved oxygen (DO) levels. Increased oxygen levels can increase aerobic metabolic activity so as to produce energy used for swimming activities and aggressive behavior. Increased metabolism requires sufficient substrate derived from fish feed. Susantie & Manurung (2018) stated, high oxygen levels can increase feed consumption in red tilapia. The feed consumed by red tilapia becomes a source of nutrition for energy production in metabolic processes, maintains survival, and supports the growth of red tilapia.

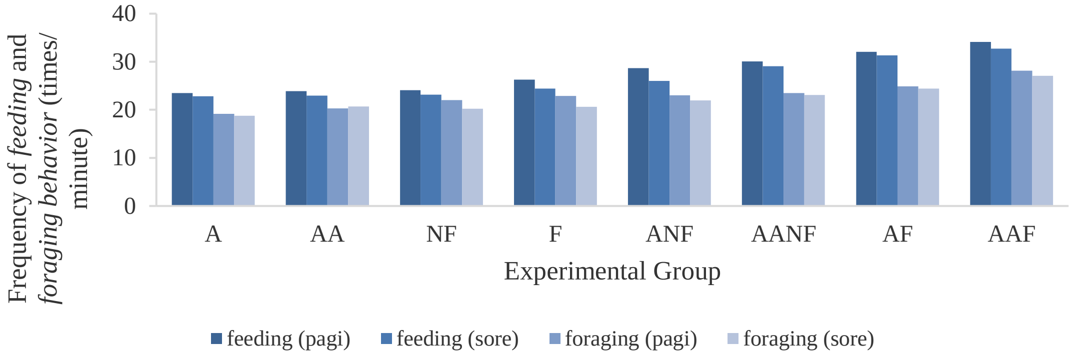

Figure 2. Frequency of Feeding Behavior (Times/Minute) on Red Tilapia in Each Experimental Group. The average frequency of feeding and foraging showed a significant difference ($P<0.05$) between the experimental groups

Availability of feed is a major factor in supporting the growth rate and health of farmed fish. The level of feed consumption is influenced by the frequency of feeding and the nutritional content of the feed. Feed that has an aroma dissolved in water can stimulate the sense of smell and the taste of food can stimulate the sense of taste of fish, as described by Adlina et al. (2014), the olfactory reaction of fish is caused by the presence of odors dissolved in water. This condition helps the fish speed up the time of taking feed. The results of this study are in line with Adlina et al. (2014) stating, the senses of sight (eyes), smell (olfactory) are used by fish to swim in finding food, and taste (gustatory) to detect feed through taste stimuli to determine whether the food is consumed or rejected.

The feed consumed by the fish will undergo a process of digestion in the digestive system before the feed nutrients are used for the biological needs of the fish. The process of digestion in the digestive system will involve the role of digestive enzymes. The process of digestion of feed obtained by fish will begin with taking food and ending with the disposal of food waste. The process of digestion of feed is assisted by digestive enzymes found in the digestive tract. This result is in accordance with the opinion (Fitriliyani, 2012) which states that feed is processed mechanically by mouth and chemically processed with the help of enzymes. The results of Chabot et al. (2016) stated that the nutrients from the digestion of feed will be absorbed by enterocytes and transported to the liver through the hepatic portal vein. Nutrients from the liver are circulated to all target cells in the body through the systemic circulation system. Nutrients will be taken up by various body cells as enzyme substrates in the metabolic process to produce energy that is used for fish growth and activity.

The results of the data analysis of schooling and surficing behavior had a significant effect (P<0.05) on the use of aerators, filters, or a combination thereof, both in the morning and evening (Table 3). Fish rearing with the use of double aerators combined with filters shows an increase in the frequency of schooling behavior which takes longer. The resting duration maintained by using a single aerator without being equipped with a filter showed an increase in duration followed by an increase in the average frequency of resting behavior (Figure 3).

Table 3. Duration of Red Tilapia Schooling and Resting Behavior (Minutes/Group) in the Morning and Evening

Experimental groups		*Schooling*		*Resting*	
			Evening	Morning	Evening
Aerator (A)	A	18,01^{b}±5,51	10,84^{a}±4,90	10,05^{b}±6,01	29,15^{b}±3,87
	AA	21,76^{a}±1,03	15,10^{b}±1,97	2,02^{a}±0,96	17,80^{a}±9,15
Filter (F)	NF	17,03^{a}±0,74	11,07^{a}±4,65	8,96^{b}±7,06	28,39^{b}±5,00
	F	18,51^{b}±4,53	14,86^{b}±2,88	3,11^{a}±1,87	18,56^{a}±9,55
Aerator x Filter	A x NF	12,75^{a}±0,47	7,57^{a}±3,58	15,42^{a}±3,01	30,75^{a}±4,85
	AA x NF	22,74^{ab}±0,91	14,58^{ab}±2,29	4,67^{b}±1,11	27,54^{b}±1,81
	A x F	22,21^{ab}±0,92	14,12^{ab}±3,78	2,51^{c}±0,91	26,02^{c}±4,24
	AA x F	23,27^{b}±0,55	15,61^{b}±1,63	1,54^{d}±0,80	9,59^{d}±2,04

a-d Different superscripts in the same column showed significantly different (P<0.05); The interaction effect between aerator and filter (aerator x filter) was significantly different (P<0.05). The data displayed is an average ± SD.

The experimental groups with dual aerators equipped with filters had high water temperatures caused by sunlight. Light that enters through the eye or the pineal region will affect fish activity through the physiological mechanism of the retina of the fish eye which is transmitted to the brain center through the central nervous system. Light stimulation causes an effect on the swimming speed of fish as a response to swimming behavior (schooling). The results of this study are in line with the opinion of Adlina (2014) which states that the eye is the main organ in the sense of sight that influences changes in behavior towards water environmental conditions. Light that collects on the retina in large quantities will cause fish to move more actively along with other fish. The effector (light) is captured by the eye on the retina in which there are photoreceptors (cones and rods) converting light energy into electrical energy (transmitters) so that it can be translated by the nervous system and forwarded to the regulator. Impulses from the brain that will produce a schooling behavior or swimming in groups with the same direction and speed brain as a central.

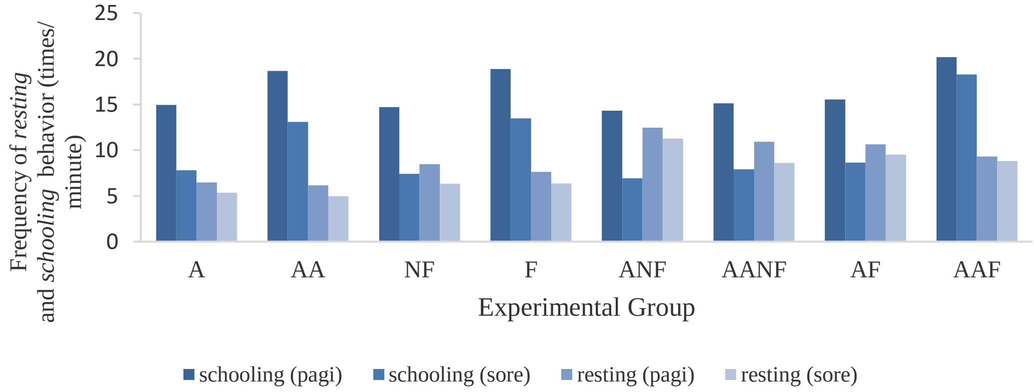

Figure 3. Frequency of Schooling and Resting Behavior (Times/Minute) on Red Tilapia in Each Experimental Group. The average frequency of schooling and resting showed a significant difference ($P<0.05$) between the experimental groups

The decrease in dissolved oxygen in the water can cause food intake to decrease. Fish are not able to meet their energy needs which results in fish movement slow in responding to feed, fish lose their appetite, and swimming speed decreases. The results of this study are in line with the opinion of Heriyati et al. (2020), poor water quality will result in a low level of fish feed consumption, reduced metabolic energy production so that the fish's body condition is getting weaker. Ridwantara et al. (2019) states, reduced feed consumption results in low energy production so that fish tend to be alone and not actively moving. Azwar et al. (2015) stated that lack of energy results in fish becoming weak and can even cause death. This condition is a result of damage to body tissues (no longer able to transport oxygen to the brain) resulting in a lack of oxygen supply to the brain. Fish will show longer resting behavior and physiological processes in the fish's body are not optimal. This condition is a compensation for fish to save energy by reducing movement activity (Rahim et al., 2015).

The observations in Table 4 and Figure 4 of the duration of the surficing and scratching behavior of red tilapia (minutes/group) in the morning and evening showed significantly different results ($P<0.05$) for the aerator, filter, or a combination thereof. The duration maintained with the use of a single aerator without being equipped with a filter showed an increase in duration followed by an increase in the average frequency of surficing and scratching behavior compared to the other three experimental groups.

Table 4. Duration of Red Tilapia Scratching and Surficing Behavior (Minutes/Group) in the Morning and Evening

Treatment		*Scratching*		*Surficing*	
		Morning	Evening	Morning	Evening
Aerator (A)	A	13,63^{b}±1,08	8,27^{b}±0,34	10,81^{a}±2,40	12,54^{b}±1,08
	AA	8,87^{a}±4,47	5,91^{a}±2,09	20,99^{b}±10,50	9,26^{a}±5,75
Filter (F)	NF	13,87^{b}±0,86	8,20^{b}±0,44	10,40^{a}±1,97	8,00^{a}±4,40
	F	8,62^{a}±4,22	5,99^{a}±2,16	21,40^{b}±10,13	13,79^{b}±1,57
Aerator x Filter	A x NF	14,60^{a}±0,49	8,51^{a}±0,12	30,50^{a}±4,85	14,45^{a}±1,69
	AA x NF	13,14^{ab}±0,34	7,89^{ab}±0,43	12,29^{b}±1,81	13,13^{b}±1,25
	A x F	12,66^{ab}±0,28	8,04^{ab}±0,34	11,47^{c}±1,29	11,94^{c}±0,38
	AA x F	4,59^{b}±0,32	3,93^{b}±0,13	9,34^{d}±2,04	4,07^{d}±2,30

a-d Different superscripts in the same column showed significantly different ($P<0.05$); The interaction effect between aerator and filter (aerator x filter) was significantly different ($P<0.05$). The data displayed is an average ± SD.

The accumulation of ammonia waste can pollute and reduce water quality. Marlina & Rakhmawati (2016) stated that nitrogen waste comes from fish farming activities, such as leftover feed, feces, and metabolites that can harm fish health. The increase in the percentage of ammonia along with the increase in the pH value of the water. Fish rearing using a single aerator without a filter showed a high degree of acidity of 6.9. This condition causes dissolved oxygen levels to decrease so that oxygen consumption decreases and feed consumption levels decrease. This condition will cause stunted growth rate. Sintiya et al. (2021) stated that the pH range of the three experimental covered the range between 8.05-8.04; 7.94-8.15, and 7.93-8.69 were still in the normal range in the survival rate of red tilapia, but inhibited the growth rate of fish.

Protein nutrition in high feed will affect ammonia levels in the waters. The availability of ammonia released by fish is related to the level of feeding and protein in the feed. Ammonia levels in the study were around 0.58 mg/L. The results of this study are in accordance with the research of Wahyuningsih & Gitarama (2020) which states that ammonia is toxic to the fish body if levels reach 0.025 mg/L by causing irritation to the fish body. The increase in ammonia is directly proportional to the increase in nitrite and nitrate. These results are in accordance with the results of the research of Sriyasak et al. (2015) which showed that high levels of nutrients can cause levels of nitrogen waste from the decomposition of organic matter such as non-biodegradable ammonia (NH3) to be toxic to fish. Nitrogen waste will increase mucus production in fish. The thick mucus produced can cause skin irritation in fish. Al-Azwar et al. (2017) stated that the pH value of water which is higher than the normal limit range can increase the production of fish mucus which is characterized by a decrease in the activity of mucosa-producing cells with antimicrobial properties. Fish have the behavior of caring for the body by rubbing the surface of the body against objects in the water environment to remove the layer of mucus attached to the fish's body.

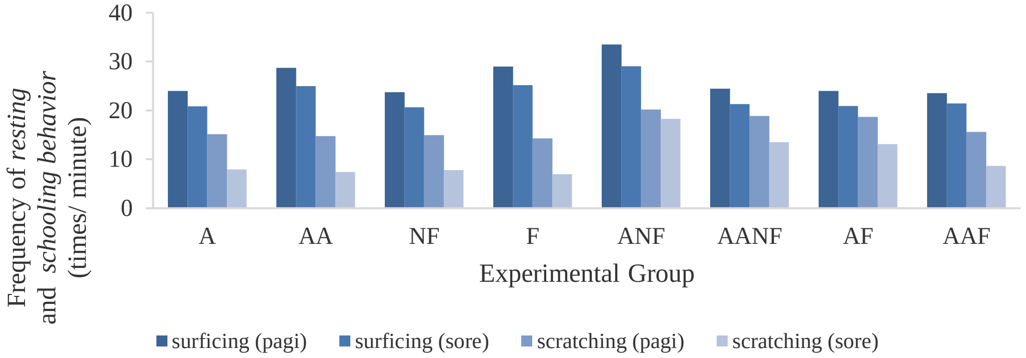

Figure 4. Frequency of Surficing and Scratching Behavior (Times/Minute) on Red Tilapia in Each Experimental Group. The average frequency of surficing and scratching showed a significant difference ($P<0.05$) between the experimental groups

The production of mucus by red tilapia can reduce gill function so that fish will find it difficult to breathe and prefer to swim on the surface of the water or show surficing behavior. This behavior is characterized by swimming movements or moving places to be faster, irregular, often coming to the surface, and swimming to the bottom of the culture pond faster. This surficing behavior indicator shows that there is discomfort in keeping fish. In line with the research of Garcia et al. (2016) stated, fish with a lack of dissolved oxygen (hypoxia) will swim near the surface of the water in order to increase dissolved oxygen levels. Putra et al. (2011) stated, decreased oxygen stimulates respiratory activity by acting on chemoreceptors to send signals to the brain to stimulate respiratory activity.

The results of the analysis in Table 5 and Figure 5 show that the aggressive behavior of red tilapia consisting of chasing, biting, and mouth pushing in the morning or evening showed significantly different results ($P < 0.05$) both with the use of aerators, filters, or the combination. This shows that red tilapia reared with a double aerator without a filter need longer time for chasing, biting, and mouth pushing than the other experimental groups. The use of an aerator combined with a filter in this study can increase aggressive behavior which is characterized by an increase in the duration and average frequency of chasing, biting or mouth pushing behavior of red tilapia in the morning and evening.

Table 5. Duration of Red Tilapia Chasing, Biting, and Mouth Pushing Behavior (Minutes/Group) in the Morning and Evening

Treatment		*Chasing*		*Biting*		*Mouth pushing*	
		Morning	Evening	Morning	Evening	Morning	Evening
Aerator (A)	A	$24{,}07^{a}\pm3{,}18$	$15{,}93^{b}\pm1{,}37$	$9{,}81^{a}\pm1{,}10$	$6{,}13^{b}\pm0{,}67$	$3{,}75^{b}\pm0{,}37$	$3{,}82^{b}\pm0{,}65$
	AA	$16{,}91^{b}\pm8{,}8$	$10{,}82^{a}\pm8{,}11$	$6{,}83^{b}\pm4{,}60$	$4{,}31^{a}\pm3{,}28$	$2{,}89^{a}\pm1{,}74$	$2{,}82^{a}\pm1{,}47$
Filter (F)	NF	$16{,}33^{a}\pm8{,}18$	$8{,}89^{a}\pm6{,}04$	$5{,}95^{a}\pm0{,}73$	$3{,}60^{a}\pm2{,}59$	$2{,}45^{a}\pm1{,}07$	$2{,}62^{a}\pm1{,}17$
	F	$24{,}65^{b}\pm3{,}32$	$17{,}86^{b}\pm1{,}20$	$6{,}71^{b}\pm3{,}42$	$6{,}84^{b}\pm0{,}77$	$4{,}19^{b}\pm0{,}87$	$4{,}02^{b}\pm0{,}85$
Aerator x Filter	A x NF	$8{,}97^{a}\pm2{,}33$	$3{,}12^{a}\pm0{,}82$	$2{,}82^{a}\pm1{,}39$	$1{,}20^{a}\pm0{,}60$	$1{,}42^{a}\pm0{,}13$	$1{,}56^{a}\pm0{,}30$
	AA x NF	$23{,}69^{d}\pm3{,}48$	$14{,}65^{d}\pm0{,}24$	$9{,}07^{b}\pm0{,}61$	$6{,}00^{ab}\pm0{,}76$	$3{,}47^{ab}\pm0{,}16$	$3{,}68^{ab}\pm0{,}49$
	A x F	$24{,}46^{b}\pm3{,}12$	$17{,}20^{b}\pm0{,}47$	$10{,}54^{c}\pm1{,}01$	$6{,}25^{ab}\pm0{,}60$	$4{,}02^{ab}\pm0{,}31$	$3{,}96^{ab}\pm0{,}81$
	AA x F	$24{,}85^{b}\pm3{,}80$	$18{,}52^{c}\pm1{,}37$	$10{,}85^{d}\pm2{,}46$	$7{,}42^{b}\pm0{,}36$	$4{,}35^{b}\pm1{,}23$	$4{,}08^{b}\pm0{,}96$

a-d Different superscripts in the same column showed significantly different ($P<0.05$); The interaction effect between aerator and filter (aerator x filter) was significantly different ($P<0.05$). The data displayed is an average ± SD.

An increase in water temperature will affect changes in fish behavior. A more active fish movement will affect the speed of feed digestion so that gastric emptying becomes faster. This condition causes a higher appetite for fish so that tilapia become more aggressive in finding and catching the feed provided. Increased aggressive behavior of red tilapia triggers the behavior of chasing and biting between fish. Aggressive behavior can reduce the quality of aquaculture pond water which can endanger the sustainability of red tilapia. Azhari et al. (2017) which states that a bad water environment, such as low dissolved oxygen availability can trigger stress in fish. Some indications of the stress response include changes in fish behavior to become more aggressive, which is marked by the emergence of chasing, biting and mouth pushing behavior between fish in grabbing dissolved oxygen levels in the water so that the fish's body is injured and damaged. This condition will cause the growth rate to be not optimal.

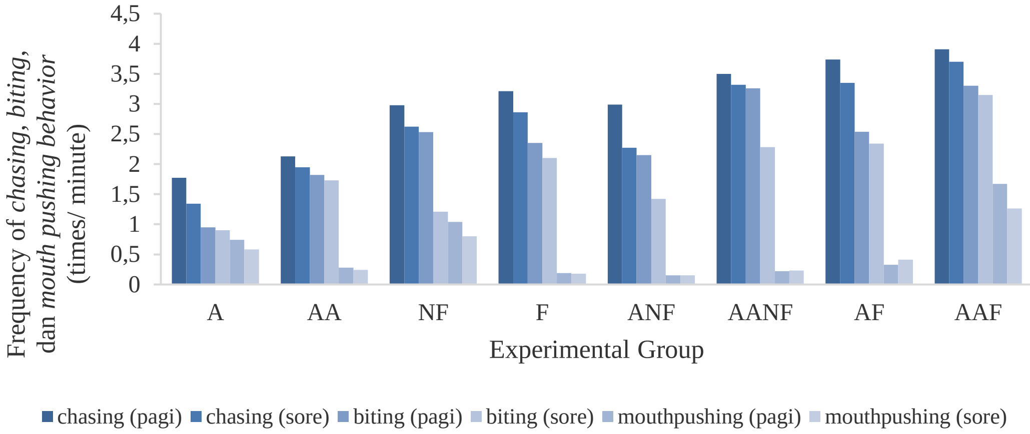

Figure 5. Frequency of Chasing, Biting, and Mouth Pushing Behavior (Times/Minute) on Red Tilapia in Each Experimental Group. The average frequency of chasing, biting, and mouth pushing showed a significant difference ($P<0.05$) between the experimental groups

CONCLUSION

The raising tilapia use of multiple aerators and filters could improve the quality of raising water so that it has a positive impact on feeding, foraging, and schooling behavior in the growth phase of tilapia.

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