Zagazig Veterinary Journal, ©Faculty of Veterinary Medicine,
Zagazig University, 44511, Egypt.
Volume 52, Number 3, p:336-345 September 2024
DOI: 10.21608/zvjz.2024.299631.1246

RESEARCH ARTICLE

The Influence of Varying Stocking Densities on the Behavioral Indices, Growth Performance, and Welfare of Grass Carp (Ctenopharyngodon idella) Fish

Hesham H. Mohammed[1], Mohamed Ebrahim[2*], Mohamed I. Youssef[1], Al-Sadik Y. Saleem[1], Adel Abdelkhalek[3]

[1] Behavior, Management of Animal, Poultry and Aquatic Department, Faculty of Veterinary Medicine, Zagazig University, Zagazig 44511, Egypt.

[2] Department of Animal Wealth Development, Faculty of Veterinary Medicine, Badr University in Cairo (BUC), Cairo, Badr City 11829, Egypt

[3]Faculty of Veterinary Medicine, Badr University, Badr city, Cairo Governorate, 11829 Egypt.

* Corresponding author Email: Mohamedattia8847@gmail.com

ABSTRACT

The aim of this research was to determine how varying stocking densities affected the behavioral traits and the biological performances of grass carp (Ctenopharyngodon idella) larvae. Larvae weighted 3.00±1.00 g were randomly distributed in three groups (G1-G3; 2 replicate/group) of low-density medium density, and high density (7, 14, and 21 fish/aquarium), respectively for 8 weeks. The findings revealed that high stocking density (21 fish/ aquarium) showed the lowest values in normal behavior with the highest values of aggressive behavior when compared to low and medium density. Low density raised fish were more active than medium and high stocking density raised fish when it came to the terms of midline crossing test, and finally there was an opposite relationship between average body weight and the stocking density, the lower the density the more weight gained and vice. We can conclude that, to achieve welfare for grass carp, stocking density should be carefully considered with suitable floor space for each fish in low stocking density as mentioned group 1 (7 fish/ aquarium).

Keywords: Carp, Management, Stress, Aggressive, and Crossing test.

Introduction

The aquaculture industry has experienced significant growth in recent decades, primarily driven by a series of innovations aimed at enhancing operational control and competitiveness, these innovations encompass a spectrum of approaches, ranging from pioneering conceptual developments to the adaptation of knowledge derived from terrestrial food production systems [1]. Nowadays, there is an increasing recognition of the significance of consuming nutritious foods, with fish gaining prominence due to its distinctive nutritional advantages, fish meat encompasses a range of macros and trace elements in abundant amount; therefore, Fish always regarded as a nutritionally valuable constituent of the human diet since the beginning of time [2]. Carps derive their nomenclature from their geographical distribution. Within China, two principal classifications of carp exist: the first comprises the Chinese carps, notably including the grass carp (*Ctenopharyngodon idella*), silver carp (*Hypophthalmichthys molitrix*), and bighead carp (*Aristichthys nobilis*). The second category encompasses the Indian major carps, which include species such as catla (*Catla catla*), rohu (*Labeo rohita*), mrigal (*Cirrhinus mrigala*), and the common carp (*Cyprinus carpio*), China's rivers are naturally habitat to grass carp. It was brought to numerous other nations primarily for biological aquatic weed and macrophytes in both natural and artificial ponds [3]. Common carp, silver carp, and grass carp are the commonly cultivated carp species [4, 5]. Besides passing carp for human consumption there are many reasons for their cultivation as carp can beneficially remove the weeds and algae by consuming it as natural source of food, this practice is very common in Egypt [6]. Stocking density, feeding methods, and management practices can significantly impact stress responses, subsequent stress tolerance, soundness of fish, and the incidence of aggression [7]. In numerous cultivated fish species, growth is inversely correlated with stocking density, due to socialization [8]. There is a direct relationship between water quality, intensive stocking density and growth performance [9]. Behavioral changes were directly linked to higher stocking density. It was also shown that at high densities, some of the fish presented aggressive and domineering behavior [10]. Countless stressors have been demonstrated to cause changes in fish, affecting feeding patterns, activity levels, and aggressive behavior [11]. One of the factors that can significantly affect a variety of behavioral responses including aggressive behavior is the stocking density [12]. For this reason, the purpose of this study is to demonstrate the influence of various stocking densities on behaviour and management of Grass carp (*Ctenopharyngodon idella*) fish to identify the ideal stocking density to allow the fish to express normal behavior and to achieve optimum growth performance to maximize productivity and to achieve fish welfare

Materials and methods

Fish rearing conditions

Grass carp larvae weighted 3.00 ± 1.00 g with 4 ± 1 cm in length were taken from central laboratory for aquaculture research at El-abbassa, Abu Hammad, Al Sharqia Governorate. Fish were kept for 15 days for acclimation. Glass tanks with following dimensions (100 x 30 x 40 cm), each one was equipped by using an air supply, thermostat-controlled heater and mercury thermometer. About a quarter of the aquarium, water was changed day after day and the whole water changed each week by water free chlorine from water reservoirs tanks. During the acclimation and trial, fish were fed on a basal diet. It was formulated in the form of dry sinking pellets, to meet the nutrient requirements of grass carp larvae, the essential components along with the chemical composition of the ration according to Sweilum *et al.* [13] was presented in Table 1.

The daily ration was divided into three portions by hand and the fish were fed thrice a day at a rate of 5% of the total body weight Feed only as much as they can consume within a period of five min [14, 15].

Table 1. Composition and chemical analysis of the basal diet for Grass carp larvae

Feed ingredients (g)	
Herring meal	20.0
Soybean meal	19.0
Yellow corn	23.0
Wheat bran	33.0
Soybean oil	3.0
Vitamin and mineral premix*	2.0
Chemical analysis	
Crude protein (%)	30.09
Ether extract (%)	7.0
Crude fiber (%)	5.60
Nitrogen free extract (%)	48.91
Ash (%)	8.40
ME (kJg1) w**	10.5
Protein/energy	118.30

Experimental design

Then fish was transported to Fish Behaviour and Management Research Unit, Department of Behaviour and Management of Animal, Poultry and Aquatic, and randomly divided into 3 groups (n = 84 fish; 28 fish/group) in two replicate for 8 weeks. Group one low density 7 (G1), group two medium density 14 (G2) and group three high density 21 (G3) fish/aquarium,

Behavioral observation

To record the different behavioral patterns the following was done: each glass tank aquarium was observed daily for 4 min at circularly predetermined time. Using scanning technique. Intervals of 1 h weekly throughout the weeks of experiment for all groups [16].

The observed behavioral patterns were recorded as the following:

1) Feeding behaviour: it means the actual consumption of food at time of feeding [17].

- Mean frequency of swimming was recorded / 4 min.

2) Swimming behavior: Swimming behavior can be defined as the act of rapid or slow swimming without showing any behavioral indices [18].

- Mean frequency of swimming was recorded / 4 min.

Body care behavior

Scratching: The act of using any hard surface as rubbing surface by fish [19, 20].

- Mean frequency of scratching was recorded / 4 min.

Aggressive behavior: That one fish fight another or starts to attack it. The following patterns was defined and recorded as previously described [19, 21-23].

- Mean frequency of aggressive was recorded / 4 min.

a) Approach: one fish moves straight forward toward another fish.

b) Chasing: The vulgar swimming of fish after another fish.

c) Fleeing: The escapism of one fish from the coming fish.

d) Spreading of fins: Exhibiting the whole length of the fins.

e) Fighting. Male fish will fight to protect their territory

Crossing test

A demarcated line was drawn to divide the glass tank from outside then the total number of crossing this line was recorded for five min according to the estimated calculation of Scott *et al.* [24].

Live fish performance

The entire population of each density was weighted biweekly; where the second weight is recorded after one month and the final weight is recorded at the end of experiment in each time the whole weight is divided by the total number to calculate the average body weight according to Khalil *et al*. [25].

Data handling statistical analysis

The numerical data were recorded, tabulated, and then analyzed using Statistical Analysis System package (SPSS version 28) [26]. Results are described as Mean ± SD. One- way analysis of variance (ANOVA) test was applied to test behavioral parameters and the differences of average body weight of fish at each density. Tukey's honesty significant test was applied where the results with (*P*- value < 0.05) were considered statistically significance.

Results

The impact of different stocking densities on normal behavior

a. Feeding behavior

Results in Table 2 demonstrated that the duration of the experiment resulted in significant difference when it came to the terms of frequency of feeding among groups ($P<0.05$). It showed that G_3 had the lowest values of frequency feeding behaviour while G_1 expressed the highest values.

b. Swimming behaviour

The findings in Table 2 indicated that the experimental period led to insignificant difference when it came to the terms of frequency of swimming among groups (*P*- value = .05). It showed that G_1 recorded the highest value of frequency of swimming behaviour compared to G_2 and G_3, where the lowest values were recorded by G3.

c. Scratching behaviour:

It was evident from the results in Table 2 that the duration of the experimental phase resulted in significant difference when it came to the terms of frequency of scratching among groups ($P<0.05$). G_2 and G_3 had the lowest values of frequency scratching behaviour while G_1 expressed the highest values.

Consequence of different stocking densities on aggressive behavior

a) Approach

The outcomes of the experiment indicated illustrated in Table (2) that there was a significant difference regarding the frequency of approach among groups ($P<0.05$). It showed that G_2 and G_3 almost had similar values of frequency approaching behaviour compared to G_1 that clearly showed the lowest values.

b) Chasing

When pointing to chasing behaviour results highlighted that the duration of the trial led to insignificant difference (*P*- value = 0.06) of frequency among groups. It showed that G_3 had the highest values of frequency chasing behaviour when compared to G_1 and G_2, while G_1 recorded the lowest value.

c) Fleeing:

Concerning the frequency of fleeing behaviour, it was evident from the data in Table 2 resulted in insignificant difference of frequency among groups *P*- value (0.8), it showed that G_2 and G_3 almost had similar values of frequency fleeing behaviour when compared to G_1 that recorded the lowest value.

d) Spreading of fins:

Empirical evidence obtained from Table 2 revealed a significant difference regarding the frequency of spreading fins among groups ($P<0.05$). G_3 had the highest values of frequency spreading of fins when compared to G_1 and G_2. G_1 recorded the lowest value.

e) Fighting:

The frequency of fighting behaviour data demonstrated insignificant difference among groups (*P*- value = 0.6). G_2 and G_3 almost had similar values of frequency fighting behaviour when compared G_1 that recorded the lowest value (Table 2).

Crossing test:

Significant difference between the groups ($P<0.05$) regarding the frequency of midline crossing as obtained from the data in Table 2. G_1 and G_2 almost had similar values of frequency midline crossing behaviour compared G_3 that nearly showed the lowest values.

Table 2. Effect of different stocking densities on the frequency of the observed Grass carp larvae behavior during 8 weeks of experiment.

Behaviour		G1	G2	G3	*P* value
Normal behaviour	Feeding	11.1 ± 3.6^{a}	9.8 ± 2.9^{ab}	7.8 ± 1.5^{b}	0.04
	Swimming	15.1 ± 3.1^{a}	7.5 ± 2.3^{ab}	5.2 ± 2.4^{b}	0.05
	Scratching	1.2 ± 0.4^{a}	0 ± 0^{b}	0 ± 0^{b}	0.03
Aggressive behaviour	Approach	2.3 ± 0.2^{b}	3.3 ± 0.2^{ab}	3.6 ± 0.4^{a}	0.045
	Chasing	3.6 ± 0.7	4.7 ± 0.7	4.7 ± 0.7	0.061
	Fleeing	0.9 ± 0.2	1 ± 0.2	1.1 ± 0.1	0.875

	Spreading of fins	2.3 ± 0.2^{b}	3.6 ± 0.3^{ab}	4.6 ± 0.6^{a}	0.012
	Fighting	0.19 ± 0.1	0.3 ± 0.1	0.3 ± 0.15	0.671
Midline crossing	Crossing test	6.6 ± 1.04^{a}	6.4 ± 0.3^{a}	2.3 ± 0.4^{b}	0.001

*The values are mean ± SD; * G1=Group one (7 fish/aquarium), G2= Group two (14 fish/aquarium) and G3= group three (21 fish/aquarium). * Letters in the same rows with different superscripts are significantly different at *P* <0.05.

Table 3 illustrated the relationship between different densities and average body weight per gram. It resulted in significant difference in the second and final weight among groups (*P*> 0.05). It showed that G_1 recorded the highest values in the terms of weight gain while G_3 recorded the lowest.

Table 3. Effect of different stocking densities on the average body weight of Grass carp larvae during 8 weeks of experiment.

Criteria	G1	G2	G3	*P* value
Initial weight	3.02 ± 0.8	3.1 ± 0.6	3.01 ± 0.7	0.966
2nd weight	3.7 ± 0.7 ^{a}	3.4 ± 0.5 ^{a}	2.7 ± 0.3 ^{b}	0.011
Final weight	4.4 ± 0.4 ^{a}	3.7 ± 0.9 ^{a}	2.8 ± 0.7 ^{b}	0.003

*The values are mean ± SD; * G1=Group one (7 fish/aquarium) , G2= Group two(14 fish/aquarium) and G3= group three(21 fish/ aquarium). *Letters in the same rows with different superscripts are significantly different at *P* <0.05.

Discussion

Stocking density can be described as the measurement of fish weight in a given amount of water [27]. In order to exhibit their natural behavioral patterns with minimal pain, stress, and fear fish need abundant space [28].

Taking into consideration the aggressive behaviour high stocking density recorded the highest values of frequency of all aggressive patterns (approach, chasing, fleeing, spreading of fins, and fighting). Aggressive patterns can be split into two phases the first one during competition for food resources and sheltering sites this phase include activities like approach, chasing and fleeing while the second phase is directly linked to dominant and subordinate relationship including more fighting and spreading of fins that eventually led to formation of the dominance hierarchy. These results were compatible with previous studies that behavioral changes were directly linked to higher stocking density and with increasing densities the frequency of aggressive behavior increased [10, 29]. At high densities, some of the fish presented aggressive and domineering behavior. Our findings also agreed with those obtained by Whiteman and Cote [30] those higher densities associated with competitive behaviour, aggression, and result in physical harm. Moreover, Manley *et al*. [31]. declared that high stocking density can either increase cannibalism by increasing the possibility of encounters between aggressors and prey or decrease cannibalism by interfering with normal territorial or aggressive behavior

Regarding the crossing test the results demonstrated that crossing test (frequency) significantly affected by stocking density, as G_1 recorded the highest values while the lowest one was recorded in G_3. This result is related to high stocking density where swimming and activity decreased with decreased space which allowed for one fish. This result agreed with the results of Bjornsson [9] who reported that water quality limits the growth of fish in higher densities; these findings agree with the findings stated by Martins *et al*. [32] who found that water quality parameters have a direct effect on swimming and activity of fish.

The findings of this study demonstrated the impact of different stocking densities on average body weight, which was significantly influenced, where final body weight was the greatest in G_1 and the lowest in G_3. These results agreed with the findings of Moniruzzaman *et al*. [33] that high stocking densities lead to problems of high mortality and poor development. It also goes hand in hand with the results of previous study [34] that competition for space and food is the main reason why the stocking density influences the development of the fish. High density limits access to food, thereby leading to poor development. Also, high stocking density can negatively affect the growth performance [35].

Conclusion

This study revealed numerous changes in the behavior of grass carp. These changes were directly linked to rearing density, high density came along with decrease in normal behavior frequency with increasing in aggressive behavior and fighting for food, which eventually led to decrease in body weight and poor welfare. Furthermore, low and medium densities recorded decrease in aggressive behavior and higher body weight. To achieve welfare for grass carp, stocking density should be carefully considered with suitable floor space for each fish in low stocking density as mentioned group 1 (7 fish/ aquarium).

Conflict of interest

The authors declare that there is no conflict of interest.

References

[1] Afewerki, S.; Asche, F.; Misund, B.; Thorvaldsen, T.; and Tveteras, R. (2023): Innovation in the Norwegian aquaculture industry. Rev. Aquac., 15:759-771.

[2] Ahmed, I.; Jan, K.; Fatma, S.; and Dawood, M. A. (2022): Muscle proximate composition of various food fish species and their nutritional significance: A review. J. Anim. Physiol. Anim. Nutr, 106:690-719.

[3] Aloden, E.T. (1996): Broodstock management: an integral part of hatchery techniques. Aqua. Farm News 14: 11-17.

[4] Hagar, D.H.S. (2014): Brief summary about aquaculture in Egypt. Egypt. J. Aquac. Mar. Biol., 1: 00003.

[5] Shaalan, M.; El-Mahdy, M.; Saleh, M.; and El-Matbouli, M. (2018): Aquaculture in Egypt: insights on the current trends and future perspectives for

sustainable development. Rev. Fish. Sci. Aquac, 26.99-110.

[6] Li, L.; Balto, G.; Xu, X.,;Shen, Y.; and Li, J. (2022): The feeding ecology of Grass Carp: A review. Rev Aquac, 15: 1335-1354.

[7] Ashley, P. J. (2007): Fish welfare: current issues in aquaculture. Appl. Anim. Behav. Sci, 104:199-235.

[8] Silva, P. C.; Souza, V. L.; Padua, D. M. C.; Dalacorte, P.C.; and Goncalves, D.C. (2000): Effect of stocking density on growth and fillet composition of tetra hybrid red tilapia, Israeli strain. In: K. Fitzsimmons and J.C. Filho (Eds.). Tilapia Aquaculture in the 21st Century. Proceed from the 5th International Symposium on Tilapia Aquaculture. Rio de Janeiro, Brazil. 2: 341-345

[9] Bjornsson, B. (1994): Effects of stocking density on growth rate of halibut (Hippoglossus hippoglossus L.) reared in large circular tanks for three years. Aquac, 123: 259-270.

[10] Ahmed, I. A.; and Maqbool, A. (2017): Effects of dietary protein levels on the growth, feed utilization and haemato-biochemical parameters of freshwater fish. Cyprinus carpio Var. Specularis. Fish. aquac. J., 1-12.

[11] Schreck, C. B.; Olla, B. L.; and Davis, M. W. (1997): Behavioural response to stress. Fish Stress and Health in Aquaculture. Cambridge Uni Press. Cambridge. 145-170.

[12] Papoutsoglou, S. E.; Tziha, G.; Vrettos, X.; and Athanasiou, A. (1998): Effects of stocking density on behavior and growth rate of European sea bass (Dicentrarchus labrax) juveniles reared in a closed circulated system. Aquac Eng,18: 135-144.

[13] Sweilum, M. A.; Abdella, M. M.; and Salah El-Din, S. A. (2005): Effect of dietary protein-energy levels and fish initial sizes on growth rate, development and production of Nile tilapia. Oreochromis niloticus L. Aquac Res., 36: 1414-1421.

[14] Scheurmann ,I. (2000): The Natural Aquarium Handbook, second edition. Baron's educational series.Hauppauge,N.Y. 156 p.

[15] Chowdhury, D. K. (2011): Optimal feeding rate for Nile tilapia . (Oreochromis niloticus) Department of Animal and Aquacultural Sciences Master Thesis 60 credits 2011 Norwegian University of Life Sciences.16.05.

[16] Dawkins, M.S. (2007): Observing animal Behaviour. Oxford University, New York, the USA.158 p.

[17] Bond, E. C. (1979): Biology of fishes. 1st edition. London Publications Inc. W.B. Sounders company. library of Congress 514 p.

[18] Chen, T.C; Ormond. R.F.G.; and Mok H-K. (2001): Feeding and territorial behaviour in juveniles of three co-existing tigger Fishes. J. Fish Biol, 59:524-532.

[19] Fall, F.M. (2005): Lab exercise: Techniques for behavioural research in guppies Bowling Green state university. Anim. Behav. Biol,420/543: 1-5.

[20] Neto, J. F.; and Giaquinto, P. C. (2020): Environmental enrichment techniques and tryptophan supplementation used to improve the quality of life and animal welfare of Nile tilapia. Aquac. Rep.,17: 100354.

[21] Ferey, D. F.; and Miller, R. j. (1972): The establishment of dominance relationships in the blue gourami. Behaviour, volume 10&11 - parts (1-2): 9-59.

[22] Barreto, R.E.; Carvalho, G.G.A.; and Volpato, G.L. (2011): The aggressive behaviour of Nile tilapia introduced into

novel environments with variation in enrichment. Zoology, 114: 53-57.

[23] Brandão, M. L.; Colognesi, G.; Bolognesi, M. C.; Costa-Ferreira, R. S.; Carvalho, T. B.; and Gonçalves-de-Freitas, E. (2018): Water temperature affects aggressive interactions in a Neotropical cichlid fish. Neotrop.ichthyol., 16:170081.

[24] Scott, G.R.; Sloman, K.A.; Rouleau, C.; and Wood, C.M. (2003): Cadmium disrupts behavioural and physiological responses to alarm substance in juvenile rainbow trout (Oncorhynchus mykiss). J. Exp. Biol., 206:1779-1790.

[25] Khalil, A.; Husseiny, W.; Fattah, A.; and Ghonimi, W. (2016): Effect of feeding with different dietary protein levels and starvation on the health, nonspecific immune parameters, behavior and histo-architectures of fantail goldfish (Carassius auratus L.). J. Vet. Sci. Technol, 7: 2-12.

[26] SPSS version 28 (2021): IBM Corp. IBM SPSS Statistics for Windows, Armonk, and NY.

[27] Ellis, T. (2001): What is stocking density? Trout News. CEFAS. 32: 35–37.

[28] FAWC, Farmed Animal Welfare Council (1996): Report on the Welfare of Farmed Fish. Surbiton. Surrey. 43 p.

[29] Cole, K. S.; and Noakes, D. L. G. (1980): Development of early social behavior of rainbow trout, Salmo gairdneri (Pisces, Salmonidae). Behav. Processes, 5: 97-112.

[30] Whiteman, A. E.; and Cote, I. (2004): Dominance hierarchies in group-living cleaning gobies causes and foraging consequences. Anim. Behav, 67: 239-247.

[31] Manley, C. B.; Rakocinski, C. F.; Lee, P. G.; and Blaylock, R. B. (2014): Stocking density effects on aggressive and cannibalistic behaviors in larval hatchery-reared spotted seatrout. Cynoscion nebulosus. Aquac, 420: 89-94.

[32] Martins, C. I.; Galhardo, L.; Noble, C.; Damsgård, B.; Spedicato, M. T.; Zupa, W.; Beauchaud, M.; Kulczykowska, E. Massabuau, J. C.; and Carter, T. (2012): Behavioral indicators of welfare in farmed fish. Fish Physiol. Biochem, 38: 17-41.

[33] Moniruzzaman, M.; Uddin, K. B.; Basak, S.; Mahmud, Y.; Zaher, M.; and Bai, S. C., (2015): Effects of stocking density on growth, body composition, yield and economic returns of monosex Tilapia (Oreochromis niloticus L.) under cage culture system in Kaptai Lake of Bangladesh. J. Aquac. Res. Dev, 6: 1-7.

[34] Ardiansyah, A.; and Fotedar, R. (2016): Water quality, growth and stress responses of juvenile barramundi (Lates calcarifer Bloch), reared at four different densities in integrated recirculating aquaculture system. Aquac, 458: 113-120.

[35] Liu, B.; Fei, F.; Li, X.; Wang, X.; and Huang, B. (2019): Effects of stocking density on stress response, innate immune parameters, and welfare of turbot (Scophthalmus maximus). Aquac. Int., 27: 1599-1612.

الملخص العربي

تأثيركثافات التسكين المختلفة علي سلوك وكفاءة نمو ورعاية أسماك مبروك الحشائش(Ctenopharyngodon idella)

هشام حسني محمد1,محمد ابراهيم أحمد2,محمد يوسف ابراهيم1,الصادق خليل يوسف1, عادل عبدالخالق3
1 قسم سلوكيات ورعاية الحيوان والدواجن والأحياء المائية, كلية الطب البيطري جامعة الزقازيق.
2 قسم تنمية الثروة الحيوانية, كلية الطب البيطرى جامعة بدر بالقاهرة, القاهرة مدينة بدر 11829,مصر.
3كلية الطب البيطرى جامعة بدر بالقاهرة, القاهرة مدينة بدر 11829, مصر.

تم إجراء هذه الدراسة للكشف عن تأثير كثافات التسكين المختلفة على السلوك والأداء البيولوجي لأصبعيات سمك مبروك الحشائش (Ctenopharyngodon idella) .تم تربية اليرقات الصغيرة (3 ± 1 جم) عند 3 كثافات تسكين مختلفة وبتكرارين ؛ كثافة منخفضة 7 (المجموعة 1)، وكثافة متوسطة 14 (المجموعة 2)، وكثافة عالية 21 (المجموعة 3) سمكة / حوض، في أحواض زجاجية بأبعاد 30 × 40 × 100 سم لمدة 8 أسابيع. أظهرت النتائج أن الكثافة العالية أظهرت أقل قيم في السلوك الطبيعي مقارنة بالكثافة المتوسطة والمنخفضة التي أظهرت أعلى معدل للسلوكيات الطبيعية. كما أظهرت النتائج أن السلوك العدواني كان أكثر انتشارًا بين الأسماك التي تمت تربيتها بكثافة تسكين عالية مقارنة بالأسماك التي تمت تربيتهابكثافة منخفضة ومتوسطة. أظهر اختبار التقاطع أن الأسماك التي تمت تربيتها بكثافة منخفضة كانت أكثر نشاطًا من تلك التي رُبيت بكثافة متوسطة وعالية. وقد خلصت الدراسة بملاحظة زيادة ملحوظة في الوزن النهائي للأسماك التي رُبيت بكثافة منخفضة، بينما أظهرت الأسماك التي رُبيت بكثافة تسكين عالية انخفاضًا ملحوظًا في الوزن النهائي على مدارأسابيع الدراسة لذلك لتحقيق رعاية الأسماك يجب الوضع في الاعتبار كثافة التسكين مع اعطاء مساحة أرضية كافية للسمك كما أشرنا في المجموعة 1 (7 أسماك/ الحوض) .