The Open Access Israeli Journal of Aquaculture – Bamidgeh

As from **January 2010** The Israeli Journal of Aquaculture - Bamidgeh (IJA) will be published exclusively as **an on-line Open Access (OA)** quarterly accessible by all AquacultureHub (http://www.aquaculturehub.org) members and registered individuals and institutions. Please visit our website (http://siamb.org.il) for free registration form, further information and instructions.

This transformation from a subscription printed version to an on-line OA journal, aims at supporting the concept that scientific peer-reviewed publications should be made available to all, including those with limited resources. The OA IJA does not enforce author or subscription fees and will endeavor to obtain alternative sources of income to support this policy for as long as possible.

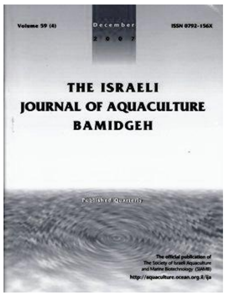
Published under auspices of
The Society of Israeli Aquaculture and Marine Biotechnology (SIAMB),
University of Hawaiʻi at Mānoa Library
&
University of Hawaiʻi at Mānoa Aquaculture Program
in association with
AquacultureHub
http://www.aquaculturehub.org

ISSN 0792 - 156X

PUBLISHER:

Israeli Journal of Aquaculture - BAMIGDEH -
Kibbutz Ein Hamifratz, Mobile Post 25210,
ISRAEL
Phone: + 972 52 3965809
http://siamb.org.il

The Israeli Journal of Aquaculture - Bamidgeh, IJA_64.2012.801, 6 pages



Effect of Stocking Density on Growth and Survival of Sub-Adult Tench (*Tinca tinca* Linnaeus 1758)

Panagiotis A. Pantazis

Department of Ichthyology, Aquatic Fauna and Fish Diseases, Faculty of Veterinary Medicine, School of Health Sciences, University of Thessaly, 224 Trikalon Street, Karditsa, P.O. Box 199, Gr-43100, Greece

(Received 7.2.12, Accepted 4.4.12)

Key words: tench, diet, deformities, ration level, growth, water recirculation system

Abstract

Three hundred and fifty-nine (359) sub-adult tench were allocated to twelve tanks to investigate the effect of stocking density on survival and growth. The experimental population consisted of two weight groups (small = 11.27-11.36 g and large = 15.38-15.44 g) and two initial stocking densities (1.4 kg/m^3 and 2.5 kg/m^3). The experiment lasted seven months (217 days). The total lack of deformities in the caudal peduncle in all groups and the low incidence of mortality indicate that sub-adult tench cultured in a water recirculation system perform well when stocked at a relatively high stocking density (2.5 kg/m^3) and fed 1.0% of their body weight per day. By the end of the experiment, the weight of the best-performing groups increased 83-90% and confirmed the hypothesis that high densities favor the growth and survival of sub-adult tench reared in artificial tanks in a water recirculation system.

* Corresponding author. Tel.: +30-24410-66020, fax: +30-24410-6604, e-mail: ppantazis@vet.uth.gr

Introduction

Tench (*Tinca tinca* Linnaeus 1758) is highly esteemed among European sport fishermen and locals due to its culinary value and highly esteemed flesh. Intensive culture of tench has crossed the borders from its traditional culturing countries (East Europe, France, Germany, Belgium, Italy) to producers in Greece, Portugal, Scandinavia, Spain (Aquamedia, 2006), and Asia (Wang et al., 2006).

Beyond its aquaculture value, tench, along with carp (*Cyprinus* spp.), is a keystone species for freshwater ecosystems, particularly in mountainous wetlands created by artificial lakes and dams (Bobori et al., 2001). An artificial lake of significant importance for Thessaly County, Greece, is Plastira Lake (39°14'39.19" N, 21°44'20.49" E) which was created as a result of the construction of a dam on the river Tavropos in 1958-1962. Lake Plastira, west of the city of Karditsa, covers 24.4 km^2, has a maximum depth of 60 m, and a capacity of 400,000,000 m^3 (Stefanidis, 2001). It is included in the Natura 2000 list of European conservation zones and classified as a Site of Outstanding Natural Beauty (FILOTIS, 2003).

The Department of Ichthyology, Aquatic Fauna and Fish Diseases of the Faculty of Veterinary Medicine of the University of Thessaly investigated the status of aquatic fauna in this reservoir and suggested a management model for its sustainable development. To this end, the Department investigated the optimum culture conditions of several keystone freshwater species (cyprinids, crayfish, etc.) in laboratory conditions to be able to supply necessary seed for repopulation.

Adult tench is an omnivore that feeds on small crustaceans, shellfish, aquatic insect larvae, and aquatic plants. Juvenile tench feed on algae. Tench avoid open, unprotected spaces and do not easily adapt to controlled culture conditions where they sometimes stop feeding due to disturbances such as handling and manipulation (Fleig and Gottschalk, 2001). Tench can adapt to water recirculation systems (Kamler et al., 2006; Wolnicki et al., 2006; Celada et al., 2007, 2009; Pantazis and Apokotou, 2009;) and feed on artificial diets in which fishmeal protein is replaced by plant protein (Pantazis and Apokotou, 2009). Juvenile tench (0.3-0.7 g) usually favor high stocking densities when cultured in intensive conditions, however, growth is not always density dependent within the range of 2-4 kg/m^3 (Celada et al., 2007).

While earlier research mostly focused on juveniles up to 5.0 g, this experiment investigated the optimum stocking density, body malformations, and growth for larger individuals (sub-adults) of 11-15 g, raised in high or low density.

Materials and Methods

Fish population and experimental set-up. The experimental population was acclimatized for a month during which it was fed a commercial carp diet manufactured by a Greek animal feed producing company (Table 1). Following acclimatization, 359 juvenile tench were randomly stocked into twelve 200-l tanks: (a) 130 individuals (11.27±1.68 g) into three tanks at a mean stocking density of 2.5 kg/m^3 (small tench, high density treatment), (b) 75 individuals (11.36±1.58 g) into three tanks at a mean stocking density of 1.42 kg/m^3 (small tench, low density treatment), (c) 100 individuals (15.38±1.68 g) into three tanks at a mean stocking density of 2.56 kg/m^3 (large tench, high density treatment), and (d) 54 individuals (15.44±1.61 g) into three tanks at a mean stocking density of 1.39 kg/m^3 (large tench, low density treatment).

All tench in every tank were sampled five times after food deprivation for 24 h: at the beginning of the experiment (day 0), on days 50, 115, and 157, and at the end of the experiment (day 217). Fish were

Table 1. Composition (%) of diets for sub-adult tench (*Tinca tinca*), dry matter basis.

	Diet	
	Acclimation[1]	*Fishmeal*[2]
Dry matter	78.00	95.04±0.15
Crude protein	34.75	38±0.3
Crude lipid	4.24	5±0.20
Ash	6.63	11±0.05
Crude fiber	6.38	6.0±0.3
NFE	48.00	40±0.5
Gross energy (kJ/g)	20.6	19.6±0.02

[1] As stated by producing company
[2] Raw materials and premixes were provided by a commercial fish-feed producing Greek company.

anesthetized by 2-phenoxy-ethanol (0.6 ml/l), the fork length was measured, and the fish were weighed on an Adam scale (ACB 1500plus, Adam Equipment Co. Ltd., UK).

Experimental tanks were components of a water recirculation system in a commercial freshwater aquaculture unit. The recirculation system comprised a header tank containing mechanical sieves and bio-rings, a sedimentation tank to which effluent water from all experimental tanks flowed, and a sump tank from which water was pumped to the header tank. The water flow rate in each tank was kept at 4 l/min. Temperature was kept at 26.5°C±0.5 (Pantazis and Apokotou, 2009) by a central water heating system. The photoperiod was kept at 12 h light:12 h dark by fluorescent lamps.

Diets and feeding. Fish were fed a fishmeal-based diet made at the Department of Ichthyology, Aquatic Fauna and Fish Diseases at the Faculty of Veterinary Medicine of the University of Thessaly, Greece (Table 1). The diet was prepared manually in a Kenwood Cooking Chef mixer (Kenwood, Hampshire, UK) and consisted of fishmeal (42%), wheat (51.5%), vegetable oil (5%), vitamin/mineral mix (1%), and carboxymethylcellulose (0.5%). Although this diet was not optimum for this species, it has been successfully used (Pantazis and Apokotou, 2009). Fish were fed at 1% of their body weight per day (Pantazis and Hatzinikolaou, 2011), taking into account that overfeeding in tench creates body deformities (Wolnicki, 2005; Kamler et al., 2006) and that faster growing individuals are more susceptible to body malformations (Myszkowski et al., 2009). Diets were given manually twice daily (09:00 and 15:00).

Water quality and analyses. Proximate composition of the diets was analyzed by methods of AOAC (2000): dry matter (952.08), ash (938.08), crude protein (Kjeldahl, modified 991.20), crude lipid (acid hydrolysis, Soxhlet), and gross energy (bomb calorimeter Gallengamp Ltd., Leicestershire, UK). Water quality was recorded once a week with a Hanna C200/HI83000 spectrophotometer: ammonia (NH_3-N) = 0.25±0.07 mg/l, nitrates (NO_3-N) = 69.6±2.31 mg/l, nitrites (NO_2-N) = 0.15±0.07 mg/l, and pH = 8.0±0.2. Oxygen and temperature were recorded daily by a Handy Polaris Oxyguard oxygen meter. Oxygen was kept at 75±5% saturation by a continuous flow of compressed air. Salinity was kept at zero as "mature" tap water was used to occasionally refill some of the water lost to evaporation. Tap water was kept in "maturation" tanks with continuous aeration to minimize the concentration of chloride ions.

Performance indices. The following indices were used to evaluate the effect of size and stocking density on fish growth and survival: specific growth rate (SGR) = 100(ln $_{\text{final body wt}}$ - ln $_{\text{initial body wt}}$/t where t is the sampling day (Steffens, 1989); feed conversion ratio (FCR) = dry wt of food consumed/wet body wt gain (Steffens, 1989); protein efficiency ratio (PER) = body wt gain/total protein ingested (Steffens, 1989); condition coefficient (K) = body wt × 10^5/total length^3 (Kamler et al., 2006).

Statistical analysis. Analysis of variance was performed by ANOVA and the Duncan multiple comparison test was used to reveal the significance of differences between treatments at the significance level of 0.05. Tests were performed using SPSS software.

Results

Mortalities were very low (1.3% for the small tench low density group, 3% for the small and large tench high density groups, 3.7% for the large tench low density group) and no deformities were observed in any treatment. By the end of the experiment, the average weight of the small and large tench stocked at high density increased 83% and 89%, respectively (Table 2). These groups started to show their superior weight gain by day 50. Condition coefficients (K) ranged 1.52-1.98. Average condition coefficients were 1.7±0.027 for the small tench high density group, 1.73±0.03 for the small tench low density group, 1.83±0.027 for the large tench high density group, and 1.84±0.025 for the large tench low density group.

Table 2. Growth and survival of small (11.27-11.36 g) and large (15.38-15.44 g) sub-adult tench (*Tinca tinca*) stocked at low (1.4 kg/m^3) or high (2.5 kg/m^3) density.

Treatment	*Day*				
	0	*50*	*115*	*157*	*217*
Small tench, high density					
Wt (g)	11.27±1.68	13.015±2.02^a	16.04±2.31^b	18.34±2.49^a	21.29±3.20^a
Wt gain (%)	-	15.48±26.8	23.24±12.4	14.34±3.01	16.08±18.35
Specific growth rate	-	0.288±0.46	0.33±0.2	0.323±0.06	0.30±0.37
Food conversion ratio	-	3.536	2.38	2.82	1.87
Protein efficiency ratio	-	0.725	1.074	0.91	1.36
Condition factor (K)	-	1.52±0.037	1.74±0.025	1.84±0.025	*
Density (kg/m^3)	2.5	2.86	3.45	3.92	4.05
Survival (no. fish)	130	129	129	128	126
Small tench, low density					
Wt (g)	11.36±1.58	12.76 ±1.91^b	15.84±2.59^a	18.1±2.49^a	19.35±2.4^b
Wt gain (%)	-	12.32±30.84	24.13±25.82	14.27±4.56	6.90±22.30
Specific growth rate	-	0.23±0.49	0.34±0.078	0.33±0.09	0.098±0.36
Food conversion ratio	-	4.12	2.87	3.03	2.83
Protein efficiency ratio	-	0.62	0.89	0.85	0.9
Condition factor (K)	-	1.55±0.03	1.76±0.013	1.89±0.02	*
Density (kg/m^3)	1.42	1.59	1.95	2.23	2.38
Survival (no. fish)	75	75	75	74	74
Large tench, high density					
Wt (g)	15.38±1.68	16.66±1.87^d	21.15±2.38^d	23.78±2.74^c	28.19±3.35^c
Wt gain (%)	-	8.32±16.74	26.95±7.74	12.44±2.79	18.55±7.81
Specific growth rate	-	0.13±0.29	0.37±0.09	0.28±0.06	0.28±0.24
Food conversion ratio	-	7.4	2.38	3.47	2.29
Protein efficiency ratio	-	0.35	1.075	0.74	1.11
Condition factor (K)	-	1.64±0.03	1.89±0.03	1.95±0.023	*
Density (kg/m^3)	2.56	2.5	3.42	3.84	4.56
Survival (no. fish)	100	99	97	97	97
Large tench, low density					
Wt (g)	15.44±1.61	15.92±1.47^c	20.48±1.76^c	22.86±2.25^b	24.16±3.32^d
Wt gain (%)	-	3.11±10.52	28.64±7.46	11.62±3.83	5.68±15.7
Specific growth rate	-	0.042±0.3	0.41±0.08	0.26±0.08	0.08 ±0.27
Food conversion ratio	-	7.5	2.33	3.78	8.6
Protein efficiency ratio	-	0.07	1.098	0.68	0.26
Condition factor (K)	-	1.69±0.034	1.94±0.025	1.89±0.33	*
Density (kg/m^3)	1.39	1.41	1.77	1.98	2.09
Survival (no. fish)	54	53	52	52	52

Letters in a column with the same superscript do not statistically significantly differ (p>0.05).
* Due to an error, total lengths were not recorded for this final sampling and condition coefficients could not be calculated.

Discussion

The high standard deviations of most performance indices of all groups during the first fifty days of the experiment confirm the peculiarity of tench, which does not adapt well to artificial culture conditions and has initial difficulty in creating homogeneous groups in terms of behavior and feeding activity (Fleig and Gottschalk, 2001). However, in due course, the fish started to behave as more homogeneous fish groups, as shown mainly by the FCR and PER.

The growth rates and weight gains indicate that tench is a slow growing species, but the gains were considerably higher than those observed earlier for this size range (Pantazis and Apokotou, 2009) and others (Quiros et al., 2003). The higher growth rates and weight gains demonstrated by Celada et al. (2007, 2009) for smaller juveniles (0.3-0.7 g) are not comparable with those of this experiment where fish ranged 11-30 g (sub-adults). Had the ration been larger (by more frequent feeding) or had the prepared diet been better refined towards the optimum nutritional requirements of the species, the growth rates and weight gains might have been even higher. However, it is questionable whether higher rations are desirable for this species and this size range because overfeeding is associated with deformities of the caudal peduncle (Kamler et al., 2006; Pantazis and Hatzinikolaou, 2011).

Mortalities were low but unavoidable as tench is quite susceptible to stress due to sampling manipulations and other disturbances (Fleig and Gottschalk, 2001). Despite the lengthy experimental period (seven months), the high density groups almost doubled their weight, significantly more than the low density groups. As a result, our hypothesis that a high stocking density of 2.5 kg/m^3 favors growth in sub-adult tench is confirmed. In addition, the lack of deformities and low mortalities indicate that sub-adult tench can live and grow well when the feeding level does not exceed 1.0% of the body weight per day.

In conclusion, sub-adult tench survive and grow well, without body deformities when stocked in water recirculation systems at relatively high density (2.5 kg/m^3) and with a daily feed ration of no more than 1.0% of their body weight. However, due to the growing economic and ecological interest in this species, higher stocking densities (>2.5 kg/m^3) in conjunction with higher ration levels, coupled with an optimal diet, are worth further study.

References

AOAC, 2000. *Official Methods of Analysis,* 17th ed. Assoc. Official Analytical Chemists, Inc., Arlington, Virginia, USA. 1300 pp.

Aquamedia, 2006. http://www.feap.info/news/default_en.asp?ID=88&LNG=1.

Bobori D., Michaloudi E., Economidis N. and T. Brouziotis, 2001. *Elaboration of Specific Management Plan for the Conservation of the Community Interest Habitat "Hard Oligo-Mesotrophic Waters with Benthic Vegetation of Chara Formations" and its Protection from Point Sources of Water Pollution*. Project LIFE99NAT/GR/6480 (in Greek).

Celada J.D., Aguilera A., Carral J.M., Sáez-Royuela M., Melendre P.M. and J.R. Perez, 2007. Effects of stocking density on survival and growth of juvenile tench (*Tinca tinca* L.). *Aquacult. Int.*, 15:461-465.

Celada J.D., Aguilera A., García V., Carral J.M., Sáez-Royuela M., González R. and Á González, 2009. Rearing juvenile tench (*Tinca tinca* L.) under controlled conditions using *Artemia* nauplii as supplement to a dry diet. *Aquacult. Int.,* 17(6):565-570.

FILOTIS, 2003. A database for the natural environment of Greece. www.itia.ntua.gr/filotis (in Greek).

Fleig R. and T. Gottschalk, 2001. Schleien im Karpfenteich. *Fischer & Teichwirt*, 52:129-131 (in German).

Kamler E., Myszkowski L., Kaminski R., Korwin-Kossakowski M. and J. Wolnicki, 2006. Does overfeeding affect tench *Tinca tinca* (L.) juveniles? *Aquacult. Int.*, 14:99-111.

Myszkowski L., Kamler E. and S. Kwiatkowski, 2009. Weak compensatory growth makes short-term starvation an unsuitable technique to mitigate body deformities of *Tinca tinca* juveniles in intensive culture. *Rev. Fish Biol. Fish.*, 20(3):381-388 (DOI 10.1007/s11160-009-9134-1).

Pantazis P. and E. Apokotou, 2009. The effect of substituting fishmeal with alternative protein sources on the growth and survival of tench juveniles (*Tinca tinca* Linnaeus 1758). *Anim. Sci. Rev.*, 40:55-62.

Pantazis P. and A. Hatzinikolaou, 2011. The effect of ration level on the growth and survival of sub-adult tench (*Tinca tinca* Linnaeus 1758). *Mar. Freshw. Behav. Physiol.*, 44(2):125-130. http://dx.doi.org/10.1080/10236244.2011.572332.

Quiros M., Nicodemus N., Alonso M., Bartolome M., Ecija L. and J.M.R. Alvarino, 2003. Survival and changes in growth of juvenile tench (*Tinca tinca* L.) fed defined diets commonly used to culture non-cyprinid species. *J. Appl. Ichthyol.*, 19:149-151.

Stefanidis P., 2001. *Torrential Environment of the Catchment Area of Lake Tavropos*. Project LIFE99NAT/GR/6480 (in Greek).

Steffens W., 1989. *Principles of Fish Nutrition*. Ellis Worwood Ltd., Chichester, West Sussex, UK.

Wang J., Min W., Guan M., Gong L., Ren J., Huang Z., Zheng H., Zhang J., Liu H. and Y. Han, 2006. Tench farming in China: present status and future prospects. *Aquacult. Int.*, 14(1-2):205-208.

Wolnicki J., 2005. Intensive rearing of early stages of cyprinid fish under controlled conditions. *Arch. Polish Fish.*, 13(Suppl. 1):5-87 (in Polish).

Wolnicki J., Myszkowski L., Korwin-Kossakowski M., Kamiński R. and LA. Stanny, 2006. Effects of different diets on juvenile tench *Tinca tinca* (L.) reared under controlled conditions. *Aquacult. Int.*, 14:89-98.