Intensive rearing of European catfish larvae (*Silurus glanis* L.) at different stocking densities and their effect on fish production parameters

***Vasilka Krasteva, Maria Yankova, Tania Hubenova**
Institute of Fisheries and Aquaculture – Plovdiv
*E-mail: vasilka_mitrova@abv.bg

Citation: Krasteva, V., Yankova, M., Hubenova, T. (2021). Intensive rearing of European catfish larvae (*Silurus glanis* L.) at different stocking densities and their effect on fish production parameters. *Zhivotnovadni Nauki*, *58*(1), 31-38 (Bg).

Abstract

During the present research, two studies are conducted (Study I and Study II), in two consecutive years, by applying the same scheme of stocking density. Each study has duration of 16 days. The object of the experiment is European catfish larvae reared in tubs with continuous water flow (0.7 $l.min^{-1}$). Throughout the experimental period, all fish are fed with „Ocean nutrition" – Canada (0.8–1.0 mm) to satiation, three times per day. At the beginning and at the end of each study, weight assessments are performed using 50 randomly selected individuals from each stocking density variant. The average weight of the larvae at the start of Study I is in the range of 50.7 ± 11.9 mg to 86.2 ± 20.1 mg and at the start of Study II – from 182.5 ± 58.0 mg to 199.3 ± 70.9 mg. The number of larvae used in Study I is 2400 and in Study II – 3600. The scheme of stocking density consists of three variants: Variant A (5 $ind.l^{-1}$), Variant B (10 $ind.l^{-1}$) and Variant C (15 $ind.l^{-1}$). In Study I, each variant of stocking density is applied with one repetition, whereas in Study II – with two repetitions for better statistical analysis.

The results from the study demonstrate that the weight gain (IWG, mg) and the survival rate (SR, %) are strongly affected by the variant of stocking density, with a significant difference being established ($P \leq 0.05$). Both parameters have the highest values for the lowest stocking density (Variant A – 5 $ind.l^{-1}$). The established values for the growth rates (AWG, DGR, SGR), for Study I and Study II, indicate that they are significantly affected by the different variants of the stocking density ($P \leq 0.05$).

Key words: European catfish, larvae, stocking density

Интензивно отглеждане на личинки европейски сом (*Silurus glanis* L.) при различна гъстота на посадката и техния ефект върху продуктивните показатели

***Василка Кръстева, Мария Янкова, Таня Хубенова**
Институт по рибарство и аквакултури – Пловдив
*E-mail: vasilka_mitrova@abv.bg

Резюме

По време на настоящото изследване са проведени две проучвания (Проучване I и Проучване II) в две последователни години чрез прилагане на една и съща схема на гъстота на посадката. Всяко проучване е с продължителност 16 дни. Обект на експеримента са личинки на европейски сом, отглеждани във вани с постоянна проточност (0,7 $l.min^{-1}$). През целия експериментален период всички риби са хранени с „Ocean nutrition" – Канада (0,8–1,0 mm), до насищане, по три пъти на ден. В началото и в края на всяко проучване е извършвано измерване на теглото на 50 произволно избрани индивида от всеки вариант на гъстота на посадката. Средното тегло на личинките в началото на проучване I е в диапазона от 50,7 ± 11,9 mg до 86,2 ± 20,1 mg и в началото на проучване II – от 182,5 ± 58,0 mg до 199,3 ± 70,9 mg. Броят на рибите, използвани в проучване I е 2400, а в проучване II – 3600. Схемата на гъстота на посадката се състои от три варианта: Вариант А (5 инд. l^{-1}), Вариант Б (10 инд. l^{-1}) и Вариант С (15 инд. l^{-1}). В проучване I всеки вариант на гъстота на посадката се прилага с едно повторение, докато в проучване II – с две повторения за по-добър статистически анализ.

Резултатите от изследването показват, че индивидуалният прираст (IWG, mg) и оцеляемостта (SR, %) са силно повлияни от варианта на гъстота на посадката с доказана степен на достоверност ($P \leq 0,05$). И двата параметъра имат най-високи стойности при най-ниската гъстота на посадка (Вариант А – 5 инд. l^{-1}). Установените стойности за темповете на растеж (AWG, DGR, SGR) за проучване I и проучване II показват, че те зависят значително от различните варианти на гъстота на посадката ($P \leq 0,05$).

Ключови думи: Европейски сом, личинки, гъстота на посадка

Introduction

In fish farming industry, European catfish is a preferred species for rearing due to its rapid growth rate, high adaptability towards wide range of ecological conditions, large body weight and high content of protein (Almazan Rueda, 2004; Zaikov, 2006). Intensive rearing of European catfish larvae to fry stage is carried out mainly in recirculation systems and systems with continuous water flow (Placinta et al., 2011).

Stocking density is one of the most important factors in the intensive rearing of European catfish larvae (Ronay and Tottkay, 1990; Wolnicki and Starzonek, 1996; Ulikowski et al., 1998; Ulikowski and Borkowska, 1999; Usov, 2011; Krol et al., 2014). Numerous authors have established that growth performance parameters can be optimized by changing the stocking density (Procarione et al., 1999; Ortuno et al., 2001; Barton et al., 2002; Offem and Ikpi, 2013; Opiyo et al., 2014; Placinta et al., 2014; Nwipie et al., 2015).

In experiments with European catfish conducted by Dokuchaeva et al. (2003), Dokuchaeva (2005) and Dokuchaeva (2011) it is established that the increasing stocking density decreases the average weight and survival rate of the larvae. These results are confirmed by Koturanov et al. (2010) and Krasteva (2020).

As a rule in fish farming, the European catfish larvae are initially reared at higher stocking densities and after 15–20 days the densities are decreased according to the specific conditions. This technology is applied by Dokuchaeva et al. (2003), Dokuchaeva (2005) and Dokuchaeva (2011) in pond culture of European catfish larvae and by Jamroz et al. (2008) in rearing of larvae in controlled conditions. Therefore, the densities in the present research are selected following the technology previously used by other researchers.

Different stocking densities are being applied by different researchers, such as: 3–15 $ind.l^{-1}$ (Szlaminska, 1986; Kaminski and Wolnicki, 1996; Wolnicki and Myszkowski, 1998; Kozlowski and Poczyczynski, 1999; Jamroz et al., 2008), 40–50 $ind.l^{-1}$ (Ageec and Dokuchaeva, 2012), 100 $ind.l^{-1}$ (Wioeniewolski, 1989; Kozlowski et al., 1995), or even up to 120–150 $ind.l^{-1}$ when the larvae are being reared with live food supply.

Another factor, affecting the rearing process, is the water quality (Hayat et al., 2018). Various stocking density experiments are conducted in different conditions related to water temperature, dissolved oxygen, nitrogens, feeding process, type of the feed, duration of the rearing, etc. As a result, the obtained data from each experiment is specific.

The aim of the present research is to establish the effect of the initial stocking density on the production parameters of European catfish larvae under controlled conditions.

Material and Methods

Study object and rearing conditions

The research is carried out at the Institute of Fisheries and Aquaculture, Plovdiv in two consecutive years – 2017 (Study I) and 2018 (Study II). The experimental unit is a production system, consisting of plastic tubs 60 x 40 x 40 cm in size and volume of 40 l with continuous water flow. The water flow rate is 0.7 $l.min^{-1}$ and complete water cycle took 43 min. Heaters and micro compressors are installed in each tub to maintain the appropriate temperature and oxygen regime of the water. For the sterilization of the water, UV lamp is used. Dead larvae are counted and removed during the daily cleaning of the tubs.

The object of the research is European catfish larvae obtained from semi-artificial propagation and reared for the aim of the experiment. Both studies have duration of 16 days. The biotechnological parameters at the beginning of the research are presented in Table 1.

For Study I, 2400 larvae at the age of 20 days, with initial body weight of 64.2 ± 18.1 mg and body length of 21.4 ± 1.1 mm are used. The larvae are distributed into three groups with two replications each and reared in three variants of experimental stocking densities: 5 $ind.l^{-1}$ (Variant A), 10 $ind.l^{-1}$ (Variant B) and 15 $ind.l^{-1}$ (Variant C). The applied experimental densities are low, in order to provide enough space for the fish and to prevent the occurrence of cannibalism.

For Study II, 3600 larvae at the age of 24 days, with initial body weight of 188.8 ± 24.6 mg and body length of 27.1 ± 1.6 mm are used. The fish are placed in tubs with the same stocking densities as in Study I, but each with three replications for better statistical analysis.

Biometric measurements are made, at the beginning and at the end of each study, on 50 randomly selected fish from each stocking density. In order to facilitate the fish manipulations, clove

Table 1. The scheme of stocking density and biotechnological parameters at the beginning of the research

Study I			
parameter	A	B	C
ISD ($ind.l^{-1}$)	5	10	15
INF (count)	400	800	1200
MIW ($mg.ind^{-1}$)	86.2 ± 20.1	55.7 ± 13.7	50.7 ± 11.9
IB (mg)	34 480	44 560	60 840
Study II			
parameter	A	B	C
ISD ($ind.l^{-1}$)	5	10	15
INF (count)	600	1200	1800
MIW ($mg.ind^{-1}$)	199.3 ± 70.9	182.5 ± 58.0	185.5 ± 51.3
IB (mg)	119 580	219 000	333 900

ISD – initial stocking density
INF – initial number of fish
MIW – mean individual weight
IB – initial biomass

oil anesthesia, with concentration of 0.02 $ml.l^{-1}$, is applied. Body weight is measured with analytical balance „Kern AEJ" (readability 0.001 g) and body length with electronic caliper „Digital Caliper" (readability 0.01 mm). Throughout the experimental period, all fish are fed with „Ocean nutrition" – Canada with pellet size 0.8–1.0 mm and protein content 55%. The European catfish larvae are fed to satiation three times per day. The food intake for each of the studied variants is established.

Production parameters

At the end of the studies, the following fish production parameters of the larvae are calculated, using the following equations:

Individual weight gain (IWG, mg): $IWG = Wt_2 - Wt_1$

Total weight gain (TWG, mg): individual weight gain*number of survived fish

Specific growth rate (SGR, $\%.day^{-1}$): $SGR = [(lnWt_2-lnWt_1)/P]^{*}100$

Average weekly growth rate (AWG, $mg.week^{-1}$): $AWG = (Wt_2-Wt_1)^{*}7^{-1}$

Daily growth rate (DGR, $mg.day^{-1}$): $DGR = (Wt_2-Wt_1)^{*}P^{-1}$

where:

Wt_1 = initial body weight;

Wt_2 = final body weight;

P = duration of the experiment (days);

Food conversion ratio (FCR): FCR = FI/TWG

where:

FI = total feed intake (g);

TWG = total weight gain (g);

Survival rate (SR, %): $SR = (NF/NI)^{*}100$

where:

NF = final number of fish;

NI = initial number of fish;

Water quality

The physicochemical parameters of the water (dissolved O_2, $mg.l^{-1}$; temperature, T °C; pH), are measured daily using a digital water checker type WTW 315. Nitrogen compounds, including nitrates (NO_3^-, $mg.l^{-1}$), nitrites (NO_2^-, $mg.l^{-1}$) and ammonium ions (NH_4^+, $mg.l^{-1}$) are monitored once a week.

Statistical analysis

The results are presented as average values ± standard deviation and are analyzed via Data Analysis (Excel 2010). Fish production indicators are analyzed using T-test (Pare two sample for means) to evaluate the significant differences among the groups, at significant level of $P < 0.05$. Water quality parameters are analyzed using descriptive statistics. Non-linear regression analysis is performed and correlation analysis (Pearson coefficient) is used to determine the correlation between the different stocking densities and fish productive parameters.

Results and Discussion

The main hydrochemical parameters of the water (T °C, O_2 and pH) are presented in Figure 1.

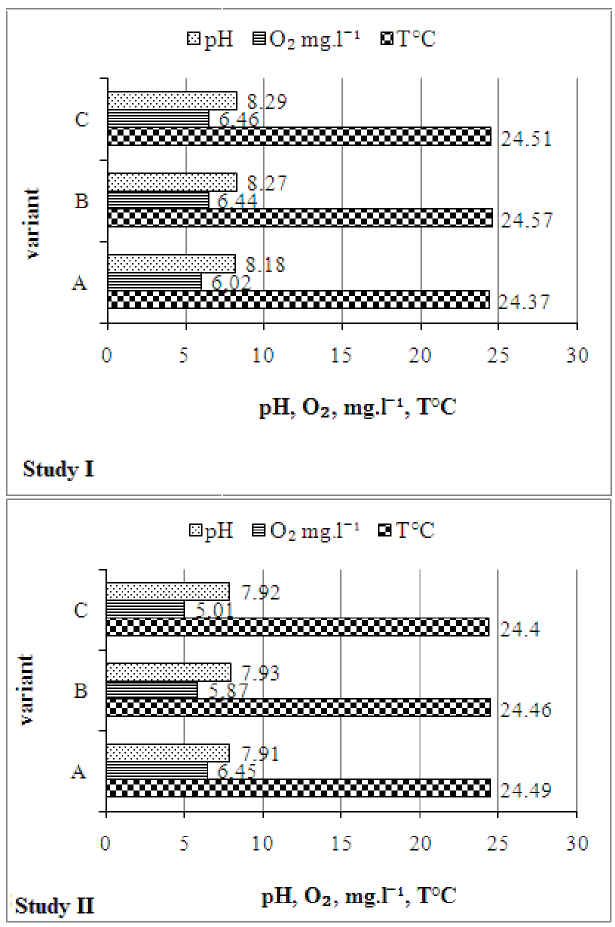

Fig. 1. Water temperature (T °C), dissolved oxygen (O_2, $mg.l^{-1}$) and pH dynamics during Study I and Study II

The temperature and the dissolved oxygen are in the optimal range. During Study II, with the increase of the stocking density, the O_2 levels begin to decrease. Critical temperature and oxygen values are not recorded during the experiment.

The average values of pH vary in the range from 7.91 to 8.29, with no significant differences in the recorded values for each stocking density.

During Study I and Study II, the highest values of ammonium ions (NH_4^+, mg.l^{-1}) are registered in Variant C (15 ind.l^{-1}). No correlation is established between the recorded values of nitrate and nitrite ions and the stocking density (Table 2).

During Study I, the highest average individual weight gain, is established in Variant A (5 ind.l^{-1}) (Table 3). With the increasing of the stocking density, the growth decreases ($P \leq 0.01$). In contrast to Study I, during Study II, the highest growth is established in Variant B (10 ind.l^{-1}) with a small difference between the values registered in Variant A and Variant C (15 ind.l^{-1}) ($P > 0.05$). The results obtained from Study I correspond to the results established by Ulikowski and Borkowska (1999), Placinta et al. (2012) and Hayat et al. (2018), who report the highest values of growth in the variants with the lowest stocking density.

During Study I, the values of the daily growth rate (DGR) and the average weekly growth rate (AWG) decrease with the increasing of the stocking density, with a significant difference being established among the groups ($P \leq 0.01$). During Study II, DGR and AWG maintained stable values that didn't change among the variants with the different stocking densities. In both experimental years, the highest specific growth rate (SGR) is reported in Variant B, but no significant difference is established ($P > 0.05$). Food conversion ratio (FCR) is influenced by the applied stocking density, with the highest values being registered for the highest density variant.

During the two experimental years, the survival rate of European catfish larvae is the highest in Variant A with the lowest stocking density ($P \leq 0.05$). When comparing the obtained results with those established by Placinta et al. (2012), it can be seen that the established survival rate by the authors from the variant with the lower stocking density (V2 – 1.46 kg/m^3) is higher, although only by 2%, from the variant with the higher density (V1 – 2.78 kg/m3) .

In Study I, the beginning of the experiment was critical for the survival of the fish. The highest mortality is registered until the 4th day, after which it sharply decreased (Figure 2). During Study II, the critical period for the fish was also in the first half of the experimental period, with the number of fish dropping from day 4 to 8 (Figure 2). The possible reason for this is the negative effect of the sorting prior to the stocking in the tubs.

Table 2. Mean, minimum and maximum values of nitrogen compounds

Study I						
variant	A		B		C	
parameter	mean	min – max	mean	min – max	mean	min – max
NO_2^-, mg.l^{-1}	0.33	0.25 – 0.39	0.33	0.23 – 0.39	0.31	0.25 – 0.37
NO_3^-, mg.l^{-1}	27.26	23.43 – 28.61	27.61	25.21 – 30.89	28.21	25.87 – 31.55
NH_4^+, mg.l^{-1}	0.34	0.11 – 0.80	0.32	0.11 – 0.97	0.36	0.11 – 0.81
Study II						
variant	A		B		C	
parameter	mean	min – max	mean	min – max	mean	min – max
NO_2^-, mg.l^{-1}	0.27	0.24 – 0.31	0.28	0.24 – 0.31	0.34	0.28 – 0.38
NO_3^-, mg.l^{-1}	15.18	13.0 – 17.03	14.75	12.81 – 16.50	15.44	13.86 – 17.03
NH_4^+, mg.l^{-1}	0.15	0.13 – 0.18	0.16	0.13 – 0.18	0.16	0.14 – 0.18

Table 3. Productive parameters of catfish growth

parameter	Study I			Level of significance
	A	B	C	
IWG (mg)	400.8 ± 12.2[a]	384.9 ± 12.0[b]	246.9 ± 12.1[c]	**
TWG (mg)	118 637[a]	195 529[b]	164 929[ba]	*
SR (%)	74.0 ± 5.7[a]	63.5 ± 4.9[b]	55.7 ± 2.3[ab]	*
AWG (mg/week^{-1})	57.2 ± 1.8[a]	46.2 ± 1.7[b]	35.3 ± 0.3[c]	**
DGR (mg/day^{-1})	25.1 ± 0.8[a]	24.1 ± 0.8[ba]	15.4 ± 0.1[c]	*
SGR (%/day^{-1})	10.9 ± 0.6[a]	13.0 ± 0.5[a]	11.1 ± 0.7[a]	NS
FCR (mg/mg)	1.1 ± 0.14[b]	1.1 ± 0.07[b]	1.3 ± 0.14[b]	NS
parameter	Study II			Level of significance
	A	B	C	
IWG (mg)	470.6 ± 140.7[a]	474.0 ± 181.1[ca]	464.2 ± 160.3[c]	**
TWG (mg)	228 712[a]	423 282[bc]	605 317[c]	*
SR (%)	81.0 ± 7.1[a]	74.4 ± 6.8[b]	72.4 ± 3.9[ab]	*
AWG (mg/week^{-1})	67.2 ± 20.1a	67.7 ± 25.9a	66.3 ± 22.9a	NS
DGR (mg/day^{-1})	29.4 ± 8.8[b]	29.6 ± 11.3[b]	29.0 ± 10.0[b]	NS
SGR (%/day^{-1})	7.5 ± 0.6[c]	7.9 ± 1.3[c]	7.7 ± 1.3[c]	NS
FCR (mg/mg)	0.9 ± 0.3[a]	1.1 ± 0.3[b]	1.1 ± 0.1[ba]	**

Values connected by different superscripts are significantly different ($P \leq 0.05$)
$^{***}P \leq 0.001$; $^{**}P \leq 0.01$; $^{*}P \leq 0.05$; NS – non significant;
IWG – individual weight gain
TWG – total weight gain
SR – survival rate
AWG – average weekly growth rate
DGR – daily growth rate
SGR – specific growth rate
FCR – feed conversion ratio

Figure 3 and Figure 4 present the correlation and regression analysis of the main production indicators (individual weight gain, IWG and survival rate, SR) in relation to the stocking density. In Study I, the Pearson coefficient (r = 0.90) determined a very strong correlation between the growth and the stocking density. The regression equation is negative, descending to lower values of stocking density which correspond to higher values of growth.

In Study II, the correlation between the growth and the stocking density is very weak to absent (r = 0.02), and the regression equation is negative (Figure 3).

Pearson coefficient determined strong dependence (r = 0.92) and a moderate to significant dependence (r = 0.57) of the survival and the stocking density, for Study I and Study II respectively. The regression equation in both studies is negative, with higher values of stocking density corresponding to higher survival rate.

Conclusion

Based on the results obtained from the two experimental years, it can be concluded that the higher stocking density, when rearing European catfish larvae, negatively affects the growth. In both studies, the highest survival (74.0 ÷ 81.0%) is reported in Variant A with the lowest stocking density.

For the rearing of 20–24 days old European catfish larvae, stocking density of 5 l^{-1} or 10 l^{-1}

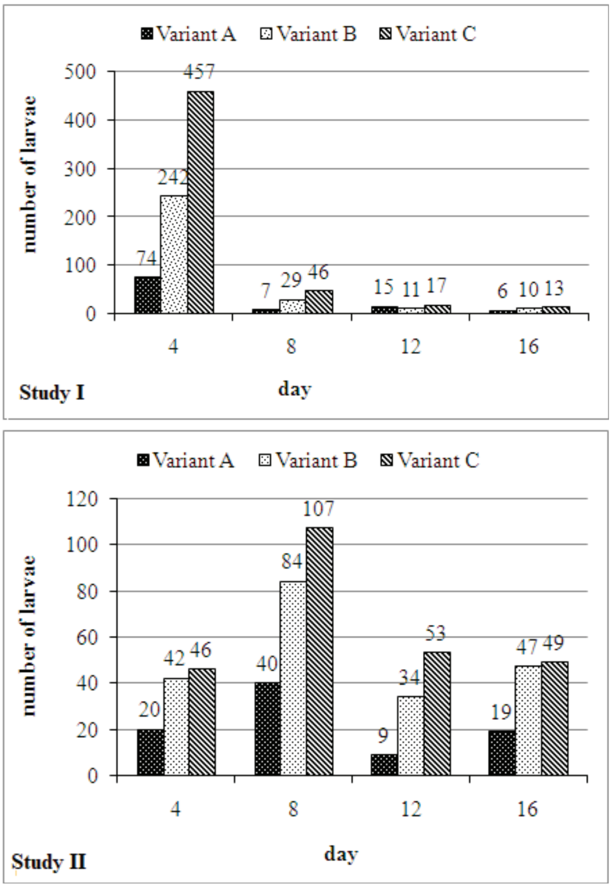

Fig. 2. Mortality rate, represented by number of dead larvae at the 4th, 8th, 12th and 16th day of Study I and Study II

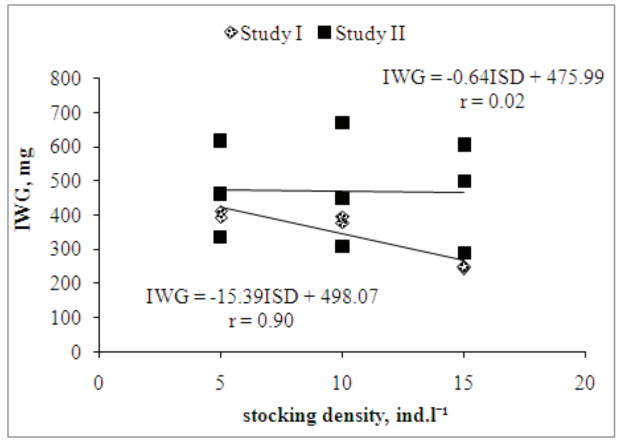

Fig. 3. Correlation between individual weight gain (IWG) and stocking density

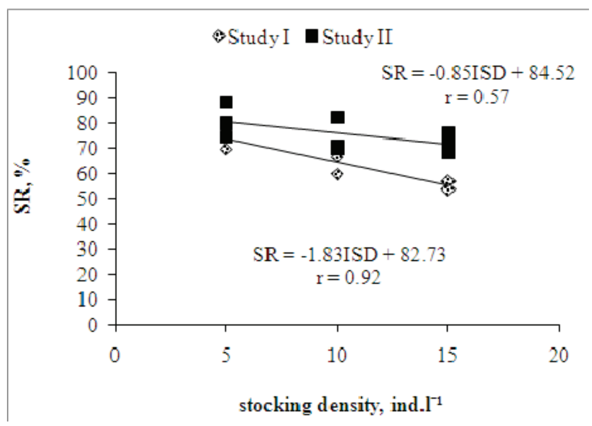

Fig. 4. Correlation between survival rate (SR) and stocking density

can be recommended. For a 16-day rearing period, at stocking density of 5 ind.l^{-1}, the expected growth is 400.8 ÷ 470.6 mg, with survival rate of 74.0 ÷ 81.0%, while at stocking density of 10 ind.l^{-1} the expected growth is 384.9 ÷ 474.0 mg and survival rate – 63.5 ÷ 74.4%.

References

Ageets, V. Y., & Dokuchaeva, S. I. (2012). Technological and biological standards for rearing European catfish in ponds in Belarus. *Issues of Fisheries in Belarus, Collection of Scientific Papers, Minsk*, *28*(1), 88-105 (Blr).

Almazan Rueda, P. (2004). Towards assessment of welfare in African catfish, *Clarias gariepinus*: the first step. *Fish Culture & Fisheries Group, Waginengen*. Institute for Animal Sciences, 1-152 (Nl).

Barton, B. A., Morgan, J. D., & Vijayan, M. M. (2002). Physiological and condition-related indicators of environmental stress in fish. In: *American Fisheries Society*, Bethesda, 111-148.

Dokuchaeva, S. (2005). The technology of rearing European catfish (*Silurus glanis* L.) in pond farms of the Republic of Belarus. Proceedings of the National Academy of Sciences of Belarus. *Series of Agricultural Sciences*, 2(1), 99-105 (Blr).

Dokuchaeva, S. (2011). Development of technological regimes for the rearing of European catfish (*Silurus glanis* L.) in pond farms in Belarus. Proceedings of the National Academy of Sciences of Belarus. *Series of Agricultural Sciences*, *2* (1), 75-86 (Blr).

Dokuchaeva, S., Konchic, V., Chutaeva, A., Federova, V., Hasenevich, A., & Sennikova, D. (2003). Biological characteristics of juvenile European catfish obtained by intensive method in pond farms in the Republic of

Belarus and technologically parameters of growth. Issues of Fisheries in Belarus. *Collection of Scientific Papers, Minsk*, *19*(1), 66-72 (Blr).

Hayat, M., Nugroho, R., & Aryani, R. (2018). Influence of different stocking density on the growth, feed efficiency and survival of Majalaya common carp (*Cyprinus carpio*, Linnaeus 1758). *F1000 Research* 2018, 7, 1917 (https://doi.org/10.12688/f1000research.16875.1).

Jamroz, M., Kucharczyk, D., Kujawa, R., & Mamcarz, A. (2008). Effects of stocking density and three various diets on growth and survival of European catfish (*Silurus glanis* L.) larvae under intensive rearing condition. *Polish Journal of Natural Sciences*, *23*(4), 850–857.

Kaminski, R., & Wolnicki, J. (1996). Successful breeding of European catfish, *Silurus glanis* L., with trout feed and some technological parameters. *Komis Rybak*, *6*(1), 4-6 (Pl).

Koturanov, P., Usov, M., Radko, M., Gadlevskaya, N., & Astrenkov, A. (2010). Growing of European catfish larvae to a viable stage on starting compound feeds. *Current Problems of the Intensive Development of Animal Husbandry*, *12*(1), 353-359 (Ru).

Kozlowski, J., & Poczyczynski, P. (1999). The effect of light and stocking density on the results of rearing of European catfish (*Silurus glanis* L.) larvae. *Archives of Polish Fisheries*, *7*(2), 297-306.

Kozlowski, J., Mamcarz, A., Poczyczynski, P., Chybowski, L., & Jozsa, V. (1995). Rearing of European sheatfish (*Silurus sglanis* L.) larvae on different dry and natural food. *European Aquaculture Society*, *24*(1), 293-297.

Krasteva, V. (2020). Influence of initial stocking density on growth performance and survival of European catfish (Silurus glanis L.) larvae under controlled conditions. *Bulgarian Journal of Agricultural Science*, *26*(1), 248-253.

Krol, J., Flisiak, W., Urbanowicz, P., & Ulikowski, D. (2014). Growth, cannibalism, and survival relationsin larvae of European catfish, *Silurus glanis* (Actinopterygii: Siluriformes: Siluridae) - attempts to mitigate sibling cannibalism. *Acta Ichthyologica et Piscatorial*, *44*(3), 191-199.

Nwipie, G. N., Erondu, E. S., & Zabbey, N. (2015). Influence of stocking density on growth and survival of post fry of the African mud catfish, *Clarias gariepinus*. *Fisheries and Aquaculture Journal*, *6*(1), 1-4.

Offem, B. O., & Ikpi, G. U. (2013). Determination of optimum stocking density for Heterobranchus longifilis (Burchell, 1822) larvae in aquarium tanks. *Journal of Fisheries and Aquaculture*, *4*(1), 52-55.

Opiyo, M. A., Ngugi, C. C., & Rasowo, J. (2014). Combined effects of stocking density and background colour on growth performance and survival of Nile tilapia (Oreochromis niloticus, L.) fry reared in aquaria. *Journal of FisheriesSciences. com*, *8*(3), 228-237.

Ortuno, J., Esteban, A., & Meseguer, J. (2001). Effects of short-term crewding stress on the gilthead sea bream (*Sparus aurata*) innate immune response. *Fish Shellfish Immunology*, *11*(1), 187-197.

Placinta, S., Cristea, V., Tiberiu, C., & Petrea, S. (2014). Hematological profile of juvenile European catfish (*Silurus glanis*) reared under different stocking densities in recirculating system conditions. *Animal Science and Biotechnologies*, *47*(1), 239-245.

Placinta, S., Ion, S., Cristea, V., Grecu, I., Mocanu, M., Coada, A., Antache, A., Bocioc, E., & Petrea, M. (2011).The influence of stocking density on *Silurus glanis* (Linnaeus, 1758) growth performance in a recirculation aquaculture system. University of Agricultural Sciences and Veterinary Medicine Iasi. Scientific papers - *Animal Husbandry Series*, *58*(1), 306-310.

Procarione, L. S., Barry, T. P., & Malison, J. A. (1999). Effects of high rearing densities and loading rates on the growth and stress responses of juvenile rainbow trout. *North American Journal of Aquaculture*, *61*(2), 91-96.

Ronyai, A., & Rottkay, A. (1990). Growth and food utilization of wells fry (*Silurus glanis* L.) fed with Tubifex worms. *Aquacultura Hungarica*, *6*(1), 193-202.

Szlaminska, M. (1986). Rearing of catfish in water with elevated temperatures. *Komis Rybak*, *6*(1), 13 (Pl).

Ulikowski, D., & Borkowska, I. (1999).The effect of initial stocking density on growth of European catfish (*Silurus glanis* L.) larvae under controlled conditions. *Archives of Polish Fisheries*, *7*(1), 151-160.

Ulikowski, D., Borkowska, I., & Chybowski, L. (1998). Use of frozen zooplankton in the intense rearing of European catfish (*Silurus glanis* L.) larvae. *Archives of Polish Fisheries*, *6* (1), 97-106.

Usov, M. (2011). Improving the semi-intensive method for the rearing of European catfish. *Current Problems of the Intensive Development of Animal Husbandry*, *14*(1), 322-329 (Ru).

Wioeniewolski, W. (1989). Breeding opportunities for catfish in ponds. *Annals of Agricultural Sciences*, 102(1), 138-166 (De).

Wolnicki J., & Myszkowski, L. (1998). Survival, growth and food conversion in European wels, *Silurus glanis* L., larvae fed commercially dry diets at 28°C. *Polish Archives of Hydrobiology*, *4*(1), 531-538.

Wolnicki, J., & Starzonek, I. (1996). Possibilities of using trout feeds and artemia cysts in the controlled rearing of catfish, *Silurus glanis* L. *Komis Rybak*, *1*(1), 21-24 (Pl).

Zaikov, A. (2006). *Aquaculture, principles and technologies*. Kabri, Plovdiv, 1-314 (Bg).