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A NEW TECHNOLOGY FOR THE INDUCED SPAWNING AND REARING OF PIKEPERCH (*Sander lucioperca* L.) TARGETING A MORE PROFITABLE PRODUCTION IN SOUTH TRANSDANUBIAN FISH PONDS

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1. INTRODUCTION, OBJECTIVES

Marketing conditions of freshwater fish in the European Union have changed radically since the turn of the millenium. Soaring prices and surplus production in the European market had a negative influence on common carp production which is one of the decisive segments of freshwater fish farming. Carp prices were not able to follow the continuously growing increase of prices of input materials (feeds, manure, Diesel oil, etc.), thus, the profitability of carp production has decreased year by year.

Currently however, there is a growing interest in several countries of the EU including Hungary – due to the significant segmentation of the market – in predator fish species that are more expensive but have an excellent meat quality.

Pikeperch (*Sander lucioperca* L.) is one of the most valuable fish species which can be sold at a high price (around 12-14 EUR/kg) on both the Hungarian and international markets without limitations in a constant demand position. Thus, the demand for pikeperch fry is significantly increasing at the fish farms of Hungary and the EU which has accelerated and stimulated research and development activities directed towards induced spawning as well as successful rearing of the species.

Earlier, in the traditional pond fish farming technology of our country predator fish species (pike, wels catfish, pikeperch, etc.) played only a secondary role, they were farmed as additional fish species to control „nuisance" fish populations even if they had a high price on the market. Of the 15-20 thousand tons of Hungarian market-

size pond fish production the proportion of predator fish species comprises only 2-3% (Szűcs, 2002). However, the share of these species is much higher (10-12%) in case of stock enhancement of natural water bodies and angling waters as recreational fishermen – anglers – appreciate these species very much. Among these, the pikeperch is one of the most popular and sough-after species by anglers.

Pikeperch with its very tasty, dry and boneless meat is one of the most valuable species of freshwater fish. It is a traditional fish in pond farms, however, it is completely new for industrial-scale production which has started only in the last few decades. Our natural waters are often classified by fishermen and anglers according to the size of stocks of this species. Its price at the market is high due to the high demand as well as the lack of developed production technology.

Unfortunately, natural stocks have decreased world wide during the last few decades; catches of fisheries have dwindled from the volume of 50 000 tons in the 1950-es to the recent amount of 18 000 tons. In the contrary, the volume of pikeperch produced in aquaculture throughout the world has grown from 50 tons in the 1950-ies to 400-900 tons in the 2000-s (FAO, 2004). During the last decades, the increased interest in pikeperch production resulted in trials on industrial-scale production of market-size pikeperch (Barry and Maison, 2004).

It is common knowledge that in Hungary pikeperch is the only fish species that is most frequently spawned in hatcheries using natural methods, onto spawning nests. Up to now, no complete

intensive hatchery spawning, fry and fingerling rearing technology exists for this important and valuable fish species that would employ hormonal stimulation.

In my dissertation, experimental investigations were conducted to reach these objectives and to contribute to the advancement of technology by the scientific results of these studies whose application could contribute to the successful and profitable production of this important fish species.

2. MATERIALS AND METHODS

In the pikeperch, the development of an induced spawning and fry rearing technology that is less dependent on environmental factors increases the safety and profitability of production. This fosters stock enhancement of natural waters and their sustainable management as well as increases pond production of pikeperch as an additional species. This directly improves profitability by producing higher volumes of a more valuable fish in addition to common carp. In addition, pikeperch reduces the undesired effect of food competition for the common carp by reducing the stocks of nuisance fish thus indirectly increasing the profitability of production.

In order to develop the technology, the following commercial-scale experiments were carried out:

- Comparative analysis of induced pikeperch spawning:

  - Semi-intensive spawning in wintering ponds (a new method of egg treatment).

  - Experiments of hormonally induced propagation using carp pituitary or analogous synthetic hormone products in combination of egg stripping.

  - Development of a methodology for a new, non-invasive induction and its application to the hatchery practice.

- A new technology and practical implications of the rearing of feeding larvae (use of cyprinid nests) as well as the presentation of economical analyses.

- Experiments on pikeperch fingerling rearing in wintering ponds on natural and formulated feeds as well as in production-size ponds in polyculture.
- Experiments on the rearing of three-year old market-size pikeperch in large-suface deep reservoirs and fish ponds.
- Economical calculations of pikeperch sales of Tógazda Zrt. in the South Transdanubian region.

2.1. Location and date of experiments

In this section, in order to find the answers for the questions raised in the objectives, experiments on induced spawning and rearing or pikeperch were conducted in the hatchery of Attalai Hal Kft. as well as in the Nagyberki, Veszprémvarsány, Marcali, Zalaszentgrót, Mike and Somogyapáti pond farms of Tógazda Zrt. in the years 2003-2011.

2.2. Comparative investigation of induced spawning of the pikeperch

2.2.1. Semi-intensive spawning. Semi-intensive pikeperch spawning experiments using spawning nests in wintering ponds

Experiments were carried out at the following 3 farms of Tógazda Halászati Zrt. in the years 2008-2010:

Zalaszentgrót winter ponds 4-5-6 size 25 m × 45 m = 1125m^2

Somogyapáti winter ponds 5-6-7 size 50 m × 25 m = 1250 m^2

Mike winter ponds 5-8-10 size 50 m × 25 m = 1250 m^2

Experiments in the year 2008 (between 16.03.2008.-28.04.2008.)

The following aspects were considered when choosing the wintering ponds:

- They should be roughly similar size,
- Complete draining should be ensured (no puddles left),
- Wintering pond bottoms should not be muddy,
- They should be disinfected before flooding with calcium hypochlorite at a dose of 25 kg/ha.

Uniform-size nests of 70 cm × 50 cm made onto a wooden frame and weighed down with lead were used at each fish farm as spawning nests. The broodstock originated from the same place, the Marcali fish farm where they were fed during the winter with topmouth gudgeon, rudd and small gibel carp. Sexes were separated on March 16th, 2008. During this period water temperature in the wintering ponds was as follows: Mike, Somogyapáti 9 °C, Zalaszentgrót 7.5 °C. Six willow root nests were placed into each wintering pond held together with a

floating plastic buoy to allow regular observation as well as to facilitate chemical disinfection of deposited eggs.

Pikeperch couples were stocked on the day of separation of sexes, March 16th, 2008. Broodfish were not treated with carp pituitary injection upon stocking. Spawning lasted for 11-16 days with a noted variation. During the first days, buoys marked the nest cleaning activity of males. By the end of spawning temperature of the water has increased to 14 °C in Somogyapáti, 14.5 °C in Mike and 13 °C in Zalaszentgrót. Following spawning, nests covered by eggs to a varying degree were immersed for a few minutes into a solution of OTC (oxytetracyclin) and Peridox to prevent bacterial and fungal infections. Earlier, an aqueous solution of malachite green was used for this purpose. However, due to the ban on the use of this chemical, a new solution had to be found which has antibacterial as well as fungicidal properties. A solution containing 6 g Peridox and 40 g OTC (oxytetracyclin) in 100 liters of water was found to be the most efficient.

Experiments were repeated in 2009 and 2010 with identical conditions.

2.2.2. Induced spawning of pikeperch in the hatchery

Experiments on induced pikeperch spawning have continuously been carried out since 2008. Optimal timing of egg stripping and signs of ovulation had to be described as the method of calculating degree-days – using only the time period after pituitary injection and

temperature – that was developed for common carp propagation was not applicable to pikeperch.

The presence of ovulated eggs was checked by entering the fish tanks and applying a gentle pressure to the abdomen of the fish. If freely flowing eggs appeared in the genital pore upon gentle pressure, the female and its male partner were transferred into an anesthetic solution. Afterwards they were placed onto a stripping desk and eggs were stripped in anesthesia.

In order to fertilize the freshly collected eggs, milt was stripped from males into a small glass vessel following a gentle pressure of the abdomen, then fertilization and water hardening of the eggs was carried out using a salt-urea solution dissolved in a 1:1 ratio with pond water. Egg batches that were hardened for approximately 30 minutes were placed into 7-liter Zuger-type hatching bottles and continuously rolled in a slow water flow until hatch. Following hatching, rising larvae were placed into 200-liter larval rearing vessels until the onset of exogenous feeding.

Experiments on induced pikeperch spawning were carried out (following preliminary tests in 2003-2006) in the years 2008-2009-2010 and 2011.

2.2.3. Development of a new non-invasive hormonal induction method in hatchery experiments of the years 2010-2011

In our use of the expression, non-invasive means that hormone products are administered to the females of a sensitive and valuable predator species such as the pikeperch without injuries through a thin

silicone catheter introduced into the ovary of the fish where it induces release of mature oocytes instead of the traditional intra-muscular or intra-peritoneal injection that produces a puncture injury. According to all available literature as well as our own experiments up to now, ovulation of pikeperch has exclusively been induced by injecting pituitary hormones intra-muscularly. For this reason, our experiments were conducted as an entirely new technological solution for induction of ovulation by administering pituitary through the genital pore. The treatment was repeated using 4 mg/kg of body weight of Percipel, as well.

The objective of experiments in 2010 was to test whether non-invasive treatment is capable of inducing ovulation in pikeperch at all. To test this, carp pituitary solution was injected through the genital pore into the ovaries of anesthetized pikeperch females. Treatments were conducted according to the following protocol in both experimental years:

Male and female fish prepared for spawning were anesthetized (1 aliquot of clove oil/1 droplet of pond water). As a result of this natural herbal oil fish entered deep narcosis in 2-3 minutes and were ready to be manipulated without injuries.

The weight of anesthetized fish was measured with digital scales and recorded into the hatchery log book. Threads of various colors were fixed to the dorsal fins in different combinations to facilitate identification.

2.3. Pikeperch fry rearing

Experiments were set up in the same ponds and wintering ponds from 2008 to 2011 in order to develop the technology of rearing 30-day old feeding larvae by selective zooplankton production. Various doses of manure and insecticides of varying active ingredients were tested in order to increase survival percentage. Smaller cyprinids were used as a new solution whose optimal individual number per 100,000 larvae was determined along with the optimal timing of flooding of ponds with Copepod-rich water.

2.3.1. Experiments on one-year old pikeperch fingerling rearing in wintering ponds using natural and formulated feeds

Experiments were conducted in wintering ponds with a surface of 0.11 ha, each. Fish were fed with natural food organisms and in separate experiments with a formulated feed (Aqua Bio trout feed with a pellet size of 0.8-1.2 mm). Feeding places were shaded.

The daily amount of experimental feed was determined in relation to the total calculated body weight present in the wintering ponds and was distributed using automatic feeders. Feeding was carried out for 10 hours a day from 8 AM until 6 PM on 3 locations in each wintering pond. A metal tray of 0.8×0.6 m was placed underneath each feeder in order to observe leftover feed. Feed pellet size was selected according to literature data as well as the experiences of previous own investigations to start with 0.8-1.2 mm which was increased to 1.3-1.6-2.2-3.0 as the fish grew. In the end of the experiment (September 20th, 2007), wintering ponds were harvested completely as the starting

fall harvests of production ponds did not allow the continuation of these experiments as the entire capacity of wintering ponds was needed. Body weight and lengt of a part of experimental fish were measured on a monthly basis along with summarized mortality values. Monthly test harvests were conducted using simple curtain nets which was followed by a short (approximately 1-hour) stop of automatic feeders and measurements of 100 fish at each event.

Table 1.: Stocking data of pikeperch fingerling rearing on formulated feeds

Number and surface of wintering ponds	Number of stocked fish	Weight of stocked fish (g)	Average weight (g)	Average length (cm)
Wintering pond 8. 1125m^2	3000	9 360	3.01±0.6	4.08±0.8
Wintering pond 9. 1125m^2	3000	10 230	3.41±0.5	4.16±0.6
Control Wintering pond 10. 1125m^2	3000	9 810	3.27±0.8	4.12±0.9

2.3.2. Experiments on pikeperch fingerling rearing in the commercial-size ponds of Tógazda Zrt. in polyculture in the years 2007-2009

The objective of our commercial-scale fingerling rearing experiments was to test how the per hectare yield of pikeperch can be increased in polyculture farming conditions. Four valley ponds of approximately equal size located on the territory of Zala and Somogy counties were appointed for these experiments. These fish ponds are positioned at the tip of the valley and are fed by the source stream directly, thus, there are no ponds on the streams above them. Thus, filtration of the flooding water allowed the formation of a nuisance-fish-free oxygen-rich habitat for the experiments in order to investigate the optimal number of pikeperch fry per hectare for fingerling rearing with the provision of food fish of various species and volume for the optimal body weight gain of pikeperch stocks. Pond number 1 (surface area 6.0 hectares) of the village Pakod in Zala county, pond number 5 outside the metropolitan area of the town of Zalaszentgrót (surface area 5.0 hectares) as well as pond number 1 (surface area 7.0 hectares) of the village Esztergályhorváti also in Zala county were selected for the experiments. Pond number 14 (surface area 7.0 hectares) of Somogycsicsó in Somogy county was used as a control but only in 2007. The depth of these valley ponds was identical and varied between 1.8-2.2 m.

2.3.3. Experiments on rearing three-year old pikeperch in polyculutre in large-surface deep reservoirs and fish ponds

Investigations were carried out in the Nagyberki (250 ha) and Somogyapáti (105 ha) fish ponds in the period of 2009-2012. Pikeperch rearing was part of the traditional fish production in polyculture. The stocked species were: common carp (2+), silver carp (2+), grass carp (2+), wels catfish (2+), pike (2+) and pikeperch (2+). The average weight of stocket pikeperch was 310-370 g while its share in the polyculture varied between 1.25-2.65%.

2.4. Statistical analysis of experimental data

Statistical analysis of the data from conducted experiments were analysed using the spreadsheet and equation editing program MS EXCEL as well as the software STATISTICA Statsoft ver. 11. Employed tests included One-way analysis of variance (ANOVA with Tukey's post hoc test), construction of correlation matrices as well as distribution analyses according to histograms. Data that equalled 0 or were outside the double standard deviation are were excluded as outliers.

3. RESULTS

3.1. *Semi-intensive spawning. Semi-intensive pikeperch spawning experiments using spawning nests in wintering ponds*

Varying correlation values were found between the weight of females and that of the collected eggs during the experimental years. A closer relationship was observed between the wet plankton which depends on the methods of pond preparation and the number of harvested fry. In standardized conditions spawning onto nests in the year 2009 produced results that were weaker by 39% regarding the number of harvested pikeperch fry than the year 2008. Water temperatures that were lower by 2 °C and the stormy windy weather following manure distribution are the suspected reasons for this difference.

Although our experiments on spawning onto nests in wintering ponds did not represent an economic loss, their efficiency was low and their success depends significantly on optimal weather conditions. A close relationship was observed in individual wintering ponds between the populations of rotifers and the number of harvested pikeperch fry. This correlation between the available food and survival is logical. However, aquaculturists have no control over many risk factors. These include for example cannibalism appearing from day 13-14 of growth. Thus, timely harvest of pikeperch fry is very important. When they reach the size of 3-4 cm harvest becomes inevitable. Otherwise, sibling cannibalism will decrease survival rate on a daily basis.

We have verified that a mixture of 6 g hydrogen peroxide and 40 g oxytetracycline (OTC) in 100 l of water is biologically more effective for the prevention and treatment of fungal and bacterial infections of pikeperch nests than the banned malachite green.

3.2. Results of induced pikeperch spawning in hatcheries

Our experiments in 2008 using carp pituitary or various synthetic analog hormones for induced spawning of pikeperch have verified that the fish reacted well to the treatment with Percipel that was improved by our team. In addition to being harmless to the organism, it also reduces the risks of viral infections. The results of treatments with Acipel did not verify the effectiveness of this hormonal product.

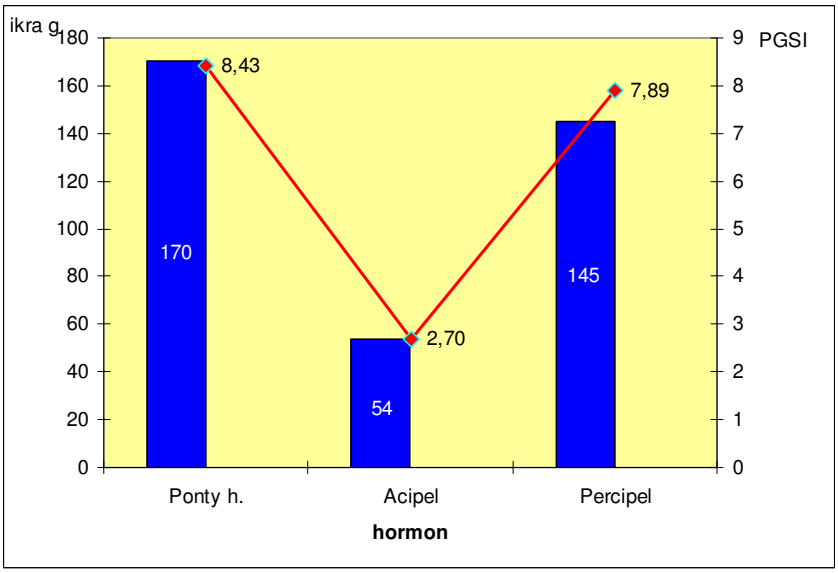

Figure 1: Egg weight and PGSI values of pikeperch females treated with various hormone products. Ikra: eggs, Ponty h.: carp pituitary.

The primary objective of this experiment was to test whether non-invasive treatment can be used to induce ovulation on the pikeperch. Earlier experiments positively confirmed this hypothesis, thus, the experiments were repeated next year with more pikeperch individuals.

Table 2.: Analysis of variance of the results of control and non-invasive treatments

treatment	**Body length cm**	**Female weight g**	**Weight of eggs g**	**PGSI %**
Traditional carp pituitary	56.60±4.86[a]	2360± 514.67[a]	148.70± 99.95[a]	6.16± 2.64[a]
Non-invasive carp pituitary	54.82±3.34[a]	2318± 413.66[a]	156.45± 85.61[a]	6.64± 2.79[a]
Non-invasive Percipel	67.11±6.72[b]	3889±1050.53[b]	536.67± 147.01[b]	14.07±3.06[b]

Superscript letters within one column represent significant difference (at confidence level $P<0.05$)

According to the results, egg release and amount of eggs as well as survival of fish treated with the new non-invasive method was better than that of the injected females. Treatments were performed in the end of the reproductive season when fish react to hormonal treatments more readily. Fertilization success of the stripped egg batches was not

followed afterwards, these deficiencies were later amended in the following spawning season.

PGSI values showed significant differences. PGSI results were relatively similar to those received with traditional pituitary injection, however, the price of modified Percipel is much lower which can facilitate its use in commercial aquaculture.

3.3. Results of pikeperch rearing experiments

3.3.1. Results of pikeperch fry rearing in wintering ponds using a new technology based on plankton selection

The following pikeperch fry survival rates (in percentages) were observed in the wintering ponds 5 days after the insecticide treatment: (Table 3.)

Table 3.: Stocking and harvest results of pikeperch fry rearing experiments in 2008 per location:

Pond/Wintering pond	Surface m^2	Stocked fry Ind.	Harvested fry Ind.	Survival %
N.	20 000	2 000 000	214 000	10.70
S 1-3	3 750	300 000	37 000	12.33
L 1-3	3 600	300 000	31 000	10.33
V 1-3	3 750	600 000	29 700	4.95

N: Nagyberki S: Somogyapáti, L: Lábod V: Veszprémvarsány

It is evident from the table that in the Veszprémvarsány wintering ponds 1-3 (where feeding fry were stocked without plankton

selection) the results are only about one third of those found in ponds where plankton selection was applied. Plankton selection with calcium hypochlorite resulted in close to 50% poorer harvest yields.

3.3.2. Pikeperch fry rearing combined with cyprinid nests

We have found no literature data on placing cyprinid nests into fry rearing ponds prior to our experiments. On the other hand, according to our observations during rearing sibling cannibalism can cause losses of up to 40-60% in fry stocks. In case of purchased feeding larvae (0.5 HUF per individual) fry rearing can lead to financial loss.

Stocking and harvest results of experiments on pikeperch fry rearing in 2010 are shown per farm and per pond in table 4. The table shows a clear relationship between placement of cyprinid nests combined with manure distribution every other day and the number of harvested fry. The concentration of REDLAN 22EC in the two ponds that produced the best results was 0,5 ppm as tested previously.

When results of the wintering ponds in Zalaszentgrót and Lábod (where no technology modification was carried out) are combined to form one average value survival rates were only 10.33 ± 1.14% while the combined result of the modified technology in the small production ponds and wintering ponds in Nagyberki, Veszprémvarsány and Somogyapáti was 16.09 ± 3.1 A significant difference was observed between the two survival rates (at a confidence level of $P<0.05$).

Table 4.: Pikeperch fry rearing experiments with cyprinid nests in 2010.

Wintering pond	Stocked fry	Cyprinid nests placed	Cyprinids Ind./100 000 fry	Harvested fry	Survival %
N	2 000 000	20	2.0	481 000	24.05
Zsz 3	300 000	0	0.0	29 800	9.93
V 1	150 000	3	2.0	19 200	12.80
2	150 000	4	2.7	21 000	14.00
3	150 000	3	2.0	20 500	13.67
S 1	100 000	2	2.0	18 100	18.10
2	100 000	2	2.0	14 400	14.40
3	100 000	3	3.0	15 600	15.60
L 1	100 000	0	0.0	11 900	11.90
2	100 000	0	0.0	10 300	10.30
3	100 000	0	0.0	9 200	9.20

N: Nagyberki, Zsz: Zalaszentgrót, S: Somogyapáti, L: Lábod, V: Veszprémvarsány

3.4. Experiments on pikeperch fingerling rearing in wintering ponds on natural and formulated feeds in 2007

By the end of the experiment total mortality (calculable) and invisible loss (non-calculable) was high, 53% and 60.1%, respectively. In wintering pond number 10 which was kept as a control, this result was only 33.90%. Although the population in the control pond had a lower individual weight and a higher individual number, lower individual weight in the control is a direct result of higher survival. With a higher individual number the growth of pikeperch fingerlings

in the control pond was slower than that of fingerlings reared on dry feed which have been reduced due to higher mortalities. We have concluded that feeding dry feeds is feasible only in more controlled conditions. According to literature data, efficiency of weaning to formulated feeds in this age group varies between 12-77% (Zakes 2003, Molnár et al. 2004). Mortalities are also high in pikeperch stocks kept in aquaria during the weaning period.

3.5. Results of pikeperch fingerling rearing in production ponds of Tógazda Zrt. in 2007-2009

Table 5.: Stocking and harvesting results of 3 years

year	2007				2008				2009			
Variable	Stocked fry	Mean harvested weight	Survival	Additional fish	Stocked fry	Mean harvested weight	Survival	Additional fish	Stocked fry	Mean harvested weight	Survival	Additional fish
unit	ind./ha	g/ind.	%		ind./ha	g/ind.	%		ind/ha	g/ind.	%	
Scs	1000	85	7	0	0	0	0	0		0	0	0
Zsz	2000	147	28	rb	3000	72	27	bvs	3000	67	38	rb
P	1000	170	22	b, vs	1000	210	25	rb	1000	110	13	ek
E h.	3000	85	9	ek	2000	156	30	rb, vs	2000	185	7	bvs

Scs:Somogycsicsó, Zsz:Zalaszentgrót, P:Pakod, Eh:Esztergályhorváti

rb: topmouth gudgeon, b: roach, vs: rudd, ek: gibel carp

Pond farms usually stock fry into fingerling rearing ponds that are rich in food fish. By the end of the season pikeperch fingerlings should reach individual length of 10-15 cm and weight of 10 g, minimum. Pikeperch fingerlings that were stocked without available food fish reached only a low individual weight. Their size was identical to those stocked at a density of 3000 individuals/ha with giber carp as food fish, however, only 7% of the stocked fish were harvested. Production ponds without an ample supply of food fish are not suitable for the culture of pikeperch fingerlings.

The experiment carried out in Zalaszentgrót in 2007 (2000 pikeperch fingerlings per hectare) produced very good results with high survival rate and high individual weight of harvested fingerlings. The 2009 stocking of pikeperch fry in Zalaszentgrót resulted in very high stocking rates, thus, the individual weight of harvested fingerlings was low. Nevertheless, this pond has produced the highest survival rate (38%) due to a good supply of topmouth gudgeon. Gibel carp fry was a poor food item for pikeperch fingerling rearing. In addition, gibel carp adults reduce the weight gain of common carp.

3.6. Results of experiments on the rearing of three-year old pikeperch in large-surface deep reservoirs and fish ponds in polyculture between 2009-2012

Results of technological innovations described in detail above were justified by the volume of harvested market-size pikeperch. Results of pikeperch rearing and yields of a 250-ha and a 105-ha pond used in polyculture are shown in table 6.

Table 6.: Rearing of market-size pikeperch in large production ponds in polyculture

Location	**Somogyapáti 105ha**		**Nagyberki 250ha**	
year	2009	2010	2008/2009	2011/2012
Total stocking kg	74 785	58 067	174 069	193 431
Pikeperch stocking kg	1 225	1 540	3 460	2 406
Pikeperch stocking ind.	3 310	4 970	10 484	6 502
Total harvested kg	249 130	236 560	598 281	606 207
Pikeperch harvested kg	3 150	4 170	6 810	7 036
Pikeperch harvested ind.	2 423	3 534	5 007	4 568
Pikeperch survival %	73.2	71.1	47.8	70.2
Pikeperch stocked ind./ha	31.5	47.3	41.9	26.0
Weight gain kg	1 925	2 630	3 350	4 630
Weight gain kg/ha	18.3	25.0	13.4	18.5
Pikeperch harvested kg/ha	30.0	39.7	27.2	28.1

The two-year average net yield of pikeperch per hectare was 20.40 ± 2.96 kg in Somogyapáti and 15.95 ± 3.61 kg in Nagyberki. These results (0.79-1.32% of the total net yield) exceded the national pond farming average (which was around 0.3% in the experimental period) by far (AKII 2010).

4. CONCLUSIONS, RECOMMENDATIONS

Experiments carried out in 2008-2010 on the semi-induced spawning of pikeperch onto nests in wintering ponds resulted in a very low number of pikeperch fry with 3-5 cm individual weight. New nest treatment methods (OTC, Peridox) applied in 2008 and 2010 were more effective in preventing bacterial and fungal infections than the traditional malachite green treatment. The aqueous solution of Peridox (hydrogen peroxide) as a strong oxydating agent combined with oxytetracycline as an antibiotic resulted in significantly higher hatch and larval survival rates than the 1:60 000 solution of malachite green that was applied in 2009. Peridox also proved to be effective against ichthyophthiriosis of pikeperch fry in our later experiments. Its efficiency has also been demonstrated against parasitoses caused by Costia sp., Trichodina sp., and Chilodonella sp.

Application to the practice: use of observations to improve the efficiency of propagation.

Modified Percipel produced gonado-somatic indices similar to the treatment with traditional acetone-dried carp pituitary. Evidently, synthetically modified Percipel produced similar or better results per injected female than pikeperch females injected with the traditional carp pituitary.

In case of the non-invasive hormonal treatment (ovarian lavage) we concluded that all treated females produced eggs capable of fertilization in 2010. We have also observed that none of the treated fish died following the process (4-6% mortalities occurred with the

invasive method used earlier). We have concluded that according to the preliminary experiments in 2010, the non-invasive method of administering hormones through a catheter can be used with high efficiency to stimulate ovulation in pikeperch females. The dose was the conventional 3.5-4.0 mg of acetone-dried carp pituitary per kg of body weight. Stripping results show that the hormone solution can be administered into the ovary through a catheter and this process will result in the ovulation of females.

No significant difference was observed in the efficiency of the traditional intramuscular hormone administration and the new one where a catheter was employed as displayed in the experiments of 2011, thus, we cannot recommend that in the future hatcheries rely on this method only. Both induction methods produced similar ovulation results. However, this completely new methodology demonstrates that pituitary hormone administered into the ovary is absorbed similarly to that injected into the dorsal muscles or into the abdominal cavity, thus, it can be used as an alternative method for the administration of biologically active products.

The following conclusions were drawn from the results of pikeperch fry rearing conducted at various geographical locations:

- Decreasing the concentration of organic phosphoric esters – RELDAN 22EC – from 2.0 mg/l to 0.5 mg/l does not result in a decrease of survival rates but rather increased that. Thus, the use of doses higher than 0.5 mg/l is not recommended for environmental and hygienic reasons.

- Stocking of cyprinids significantly increased pikeperch survival rates and total body weight in the wintering ponds.
- Results of experiments on feeding formulated feeds have shown that advanced pikeperch fry cannot effectively be weaned to artificial diets in pond conditions at the stocking rate of 10 individuals per m^2.
- Intensive conditions cannot be guaranteed in small ponds or wintering ponds that are directly linked to natural watercourses. Thus, production of pikeperch fry on dry feed cannot be economical at the current level of technology and in the presented experimental conditions.
- In our experiments, the optimal stocking density of pikeperch fry for fingerling rearing was 2000 individuals per hectare in hard-bottom ponds with ample supply of food fish and high oxygen concentrations (above 6 mg/l) throughout the year. Stocking of topmouth gudgeon, roach and rudd at a volume of 50 kg/ha into the experimental ponds has significantly increased survival rates and total fingerling weight of harvested pikeperch.

In case of market-size pikeperch production, best results were achieved by stocking 35-40 individuals of good condition and 300 g individual weight per hectare in production-size ponds.

Growth of various cohorts of pikeperch in polyculture in the South Transdanubian fish ponds depends on the species composition and volume of available food fish. Topmouth gudgeon and rudd had a positive effect on survival and growth of pikeperch in polyculture

conditions. Gibel carp fry did not prove to be a good food item for pikeperch fingerlings and stocked gibel carp adults reduced the weight gain of common carp.

5. NEW SCIENTIFIC RESULTS

1. A biologically more effective chemical combination was developed for the treatment and prevention of bacterial and fungal infections of pikeperch nests instead of the banned malachite green. The chemical consists of 6 grams of Peridox (hydrogen peroxide) and 40 grams of oxytetracycline (OTC).
2. A new analogous hormone product, Percipel was developed further for hormone induced spawning in hatcheries which has has a higher biological efficiency than carp pituitary. The costs of this product is only one fifth of the carp pituitary.
3. A non-invasive hormonal induction methodology was developed whereby carp pituitary (or its synthetic analogues) are administered by a special catheter through the genital pore directly into the ovary to induce ovulation. This represents an entirely new technological solution.
4. A new phosphoric acid ester was tested for the plankton selection before stocking pikeperch larvae instead of FLIBOL and UNIFOSZ 50EC that were used earlier and recently banned. The optimal concentration of this chemical for temporary reduction of copepods was also determined. This product is called RELDAN 22EC (225g/l chlorpyrifos-methyl), and it allows the bloom of rotifers and ciliates following elimination of copepods at the dose of 0.5 mg/l.
5. Pikeperch fry rearing technology was modified by changing the dose and distribution regime of manure. Accordingly, best

results were achieved by distributing 1 t/ha of basic manuring and 0.2 t/ha of additional manuring every other day. Optimal timing of flooding the ponds with water containing larger zooplankton was determined and sibling cannibalism was significantly reduced by placing cyprinid nests into the ponds (2 nests per 100 000 larvae). This has also increased the number and body weight of harvested fry.

6. Optimal stocking density of pikeperch fingerling rearing in polyculture was determined (2000 individuals per hectare) together with the ideal volume and species composition of food fish. This includes topmouth gudgeon and rudd at the volume of 30-50 kg/ha.

6. LIST OF PUBLICATIONS

Scientific publications in Hungarian:

1. Szathmári L., Káldy J., **Németh Á**.,Szilágyi G., Hancz Cs., (2009) A hazai halfogyasztási szokások és a magyarországi halpiaci tendenciák alakulása napjainkban Élelmiszer Táplálkozás és Marketing 2009/1-2 81-85 o.

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3. **Németh Á**., Horváth L., Szathmári L.(2013) Új szaporítási módszerek vizsgálata és alkalmazása a fogassüllő (*Sander lucioperca L.*) tenyésztésében Acta Agronomica Ovariensis megjelenés alatt

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2. **Á. Németh**, K. Orbán, P. Faidt, Á. Horváth, T. Müller, L. Szathmári, B. Urbányi[4], L. Horváth (2012) Induction of ovulation in the Pikeperch (*Sander lucioperca L.*) by ovarian lavage Journal of Applied Icthyology Vol 28 Iss 6 pp 914-915 **IF 0,902**

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1. Szathmári L., Zsédely E., Káldy J., **Németh Á.** , Varga L., Szilágyi G., Hancz Cs., Molnár E.(2011) Zsírsav struktúra alakulása a fehér busa (Hypophthalmichthys molitrix) alapú feldolgozott termékeken LIII Georgikon Napok Keszthely 117. o.
2. **Adam Nemeth**, Kornel Orban, Petra Faidt, Akos Horvath, Tamas Muller, Laszlo Horvath (2011) Introduction of ovulation in the pike pearch *(Sander lucioperca L.*) by ovarian lavage 3rd International Workshop on the Biology of Fish Gametes pp 112.

Publications in professional journals:

1. **Németh Ádám** – Kovács Éva – Csorbai Balázs – Béres Beatrix – Urbányi Béla – Horváth László (2011) A süllő lárva (*Sander lucioperca L.*) előnevelése sekélyvizű halastóban Halászat 2011. 3-4 sz. 68-74 o.

2. Rónyai András – **Németh Ádám** (2006) Süllőtenyésztés – ma I. Irodalmi áttekintés Halászat 2006. 3. sz.112-118 o.