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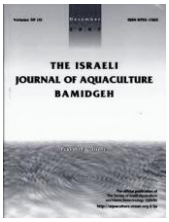

Comparison of Growth in Pike-Perch (*Sander lucioperca*) and Hybrids of Pike-Perch (*S. lucioperca*) × Volga Pike-Perch (*S. volgensis*)

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Abstract

Growth of intensively cultured pike-perch *Sander lucioperca* (L.) and hybrids of pike-perch females × Volga pike-perch (*S. volgensis* Gmelin, 1789) males (1.75 g) were compared in a 35-day experiment. Fish were sorted into three groups (50 fish/aquarium): *S. lucioperca* grown separately (Group P), hybrids grown separately (Group H), and a mixed group of 25 *S. lucioperca* (Group Mp) grown together with 25 hybrids (Group Mh). The stocking density was 0.44 g/l. Final body weights were 6.83 g, 6.54 g, 5.17 g, and 4.84 g, and specific growth rates were 3.9%/day, 3.75%/day, 3.1%/day, and 2.89%/day, for groups Mp, P, Mh, and H, respectively. The weight, length, and specific growth rates of the *S. lucioperca* were significantly higher ($p<0.05$) than those of the hybrids, whether grown separately or together. The feed conversion rate of the hybrids grown separately was significantly higher (1.28 g/g) than all other groups. Further investigation is needed to study the growth performance of larger hybrids, to compare the hybrid with *S. volgensis*, and to investigate the possibility of cross hybridization.

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Introduction

Inter-specific hybrids are produced to increase growth rate, combine desirable traits of two species, reduce unwanted reproduction by raising sterile or monosex stocks, take advantage of sexual dimorphism, increase harvestability, and increase environmental tolerance (Bartley et al., 2000). Species of the genus *Sander* have been hybred. Thanks to its better growth and lower sensitivity to environmental conditions (Siegwarth and Summerfelt, 1990), the hybrid saugeye (*Sander vitreus* × *S. canadensis*) is widely used in North American aquaculture and is stocked in natural waters for angling proposes (Tew et al., 2006) and as a predator to reduce recruitment and improve growth and size structure of overabundant crappie (*Pomoxis* spp.) populations (Galinat et al., 2002).

Pike-perch (*S. lucioperca*) is one of the most valuable freshwater carnivorous fishes in Europe, not only as a food fish but also as a sport fish (Schulz, et al., 2007). Rearing pike-perch on formulated feed is one way to intensify its production (Molnár et al., 2004, 2007; Zakęś et al., 2006; Kestemont et al., 2007; Schulz et al., 2007). Volga pike-perch, *S. volgensis* (Gmelin, 1789), belongs to the same genus as *S. lucioperca* but its growth in nature is slower; it rarely exceeds 0.5 kg, and it is less sensitive to environmental conditions. *Sander volgensis* can be found in water containing low levels of dissolved oxygen (Pintér, 2002). Early attempts to feed dry feed to *S. volgensis* suggest that its intensive rearing is possible (Bercsényi et al., 2001; Molnár et al., 2006).

The hybridization of *S. lucioperca* and *S. volgensis* in nature is rare (Müller et al., 2010), probably because of the differences in their reproductive ethology (Balon et al., 1977). The crossing of *S. lucioperca* females × *S. volgensis* males can be induced in the laboratory with common propagation practices; likewise, parental species can be bred in the laboratory (Müller et al., 2004). The aim of our work was to compare juvenile growth of *S. lucioperca* and a hybrid of the two species under laboratory conditions.

Materials and Methods

It is impossible to make a simultaneous three-way comparison between *S. lucioperca*, *S. volgensis*, and their hybrid because the reproduction and growth of *S. lucioperca* and *S. volgensis* significantly differ. Newly hatched larvae of *S. lucioperca* (5.04±0.05 mm, Ostaszewska, 2005) are larger than those of *S. volgensis* (3.25±0.17 mm, Müller et al., 2009) and the growth rate and final size of *S. lucioperca* in natural waters exceed those of *S. volgensis*. In Lake Balaton, Hungary, *S. lucioperca* grows to 145 mm during the first year (Bíró et al., 1998), while *S. volgensis* require more than two years to reach the same size (Specziár and Bíró, 2003). Therefore *S. volgensis* must be spawned one or two months earlier than *S. lucioperca* to obtain fingerlings of 3-4 cm that can be weaned from live food to formulated feed and to start a comparative experiment.

Fish. Larvae of *S. lucioperca*, originated from artificial propagation, were stocked in the fish farm of Makkos & Társa Kft. in Fonyód, Hungary. Pond-nursed juveniles were raised under natural conditions with zooplankton in

monoculture, harvested at 3-4 cm, and transported to the Fish Laboratory of Pannon University, Georgikon Faculty of Agriculture, for acclimation to artificial conditions and weaning to dry feed.

Broodstock for hybridization originated from Aranyponty Zrt., a commercial fish farm in Sáregres-Rétimajor, Hungary (*S. lucioperca*), and from natural catches in Lake Balaton in Balatoni Halászati Zrt., Siófok, Hungary (*S. volgensis*). The parent stock was acclimatized for one month before breeding. Spawning of female *S. lucioperca* was induced by gradually increasing the temperature in the tanks from 5°C to 14°C during 8 days and hormonal treatment with 250 IU human chorion gonadotropin (hCG) and 6 mg carp pituitary per fish on day 4 plus 500 IU hCG per fish on day 5. Males of both *Sander* species were injected with a single dose of 4 mg dry carp pituitary extract per kg body weight 24 h before milt stripping. Eggs of *S. lucioperca* were fertilized by *S. volgensis* milt and incubated in a Zuger jar. Hybrid fry were grown exclusively on live food, first *Paramecium* and then *Artemia* and *Chironomus* larvae, for two months until they reached 3-4 cm body length.

At 3-4 cm, hybrid and *S. lucioperca* juveniles were weaned for two weeks onto Nutra 2.0, an extruded crumbled trout starter, with *Chironomus* larvae as a live food supplement. The weaned fish were reared in a recirculation unit.

When the juveniles reached an average body weight of 1.75 g, three triplicate groups were formed. The first contained *S. lucioperca* juveniles (50 per aquarium), the second group contained hybrids (50 per aquarium), and the third contained 25 *S. lucioperca* juveniles plus 25 hybrids (per aquarium). In the third (mixed) group, hybrids were distinguished from *S. lucioperca* by their striped pattern and the size of their canine teeth (Specziár et al., 2009). At that time the hybrid juveniles were 101 days old and the *S. lucioperca* juveniles were 78 days old.

The fish were stocked in 400-l aquaria with a recirculation system and flow rate of 4 l/min. The aquaria were separated by an adjustable screen into two sections of 200 l for better feed acceptance, easier observation, and reduced daily maintenance (Fig. 1). Fish were stocked at 50 fish per aquarium (0.44 g/l). Light in the culture room fluctuated 10-50 lux. Except for the front, the walls of the aquaria were covered with gray plastic sheets to reduce light.

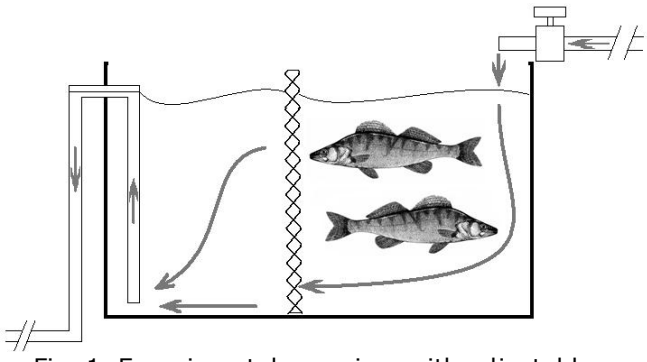

Fig. 1. Experimental aquarium with adjustable screen.

Feeding. The fish were fed Nutra 0 extruded crumbled trout starter for three weeks, followed by Classic Marine 1st P marine grower pellets for two weeks. Both feeds were manufactured by Hendrix Spa, Nutreco, Italy (Table 1). Feed was offered from automatic belt feeders for 12 h daily, 8:00-20:00. The

Table 1. Proximate composition of compound feeds (according to manufacturer).

	Feed		
	Nutra 2.0	*Nutra 0*	*Classic Marine*
Particle size (mm)	0.7-1.1	1.0-1.7	1.7
Crude protein (%)	54	54	50
Crude fat (%)	18	18	12
Crude ash (%)	10	10	10.5
Crude fiber (%)	0.6	0.6	1.5
Digestible energy (MJ/kg)	19.4	19.4	16.5

daily feeding rate was 3% of the body weight, revised weekly.

Water quality. Water temperature was maintained at 22.3± 0.5°C and dissolved oxygen at 7.2±0.5 mg/l. Both parameters were monitored daily. Mean values±SD were 7.8±0.4 pH, 0.022±0.01 mg/l nitrite, 27.65± 0.99 mg/l nitrate, 0.0425± 0.0065 mg/l ammonium, and 1.58±0.2 mg/l phosphate, mea-sured on days 1, 15, and 35.

Data collection and statistical analysis. Standard body length (to 1 mm) and body weight (to 0.1 g) of all fish in each group were recorded *e*very week and the following parameters were calculated: condition factor (K) as $100 \times w_t/(l_t)^3$, where w_t and l_t are the body length and weight at time $_t$; specific growth rate (SGR) as $100 \times (\ln w_t - \ln w_0)/t$, where w_0 is the initial weight and t is the day of the observation; and feed conversion rate (FCR) as $F/(W_t - W_0)$ where F is the total feed intake (dry weight). Statistical analyses were carried out with SPSS 7.5 for Windows (1996). One-way ANOVA with Tukey's test was used to compare growth rates, SGR, and FCR. Differences were considered significant when $p<0.05$.

Results

Growth rates significantly differed from the first week of the trial (Fig. 2). The final body weights of *S. lucioperca* ranged 4.2-11.6 g when raised separately and 4.3-10 g when raised together with hybrids; final weights of hybrids ranged 3-6.9 g when raised separately and 3.6-8 g when raised together with *S. lucioperca*. In both *S. lucioperca* and the hybrids, the average body weight was higher when they were raised together than when they were raised separately although the differences were not significant (Table 2). Growth performance was significantly lower in the hybrids than in the *S. lucioperca*. There was no mortality during the experiment.

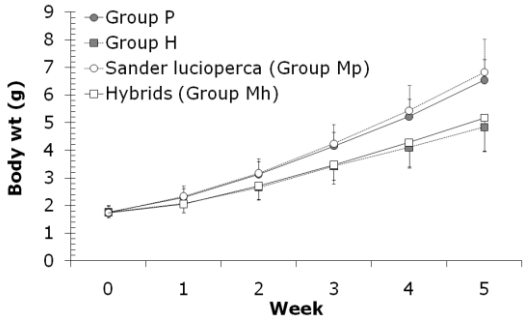

Fig. 2. Growth of *Sander lucioperca* (Group P) and hybrid *S. lucioperca* × *S. volgensis* (Group H) grown separately, and *S. lucioperca* (Group Mp) and hybrids (Group Mh) grown together.

Discussion

The objective of the present study was to compare growth of the hybrid *S. lucioperca* × *S. volgensis* with that of *S. lucioperca*. While *S. lucioperca* grows better than *S. volgensis*, it is one of the most sensitive fish species. The aim of the hybridization was to combine the favorable features of both species and see if the hybrid shows heterosis in some traits.

Table 2. Growth of juvenile *Sander lucioperca* and hybrids of *Sander lucioperca* × *S. volgensis* (mean±SD).

	Grown separately		*Grown together*	
	Sander lucioperca (Group P)	*Hybrids (Group H)*	*Sander lucioperca (Group Mp)*	*Hybrids (Group Mh)*
Initial body wt (g)	1.76±0.23	1.76±0.25	1.74±0.17	1.75±0.16
Final body wt (g)	6.54±1.19^{a}	4.84±0.76^{b}	6.83±1.19^{a}	5.17±0.89^{b}
Daily weight gain (g)	0.14±0.003^{a}	0.09±0.003^{b}	0.15±0.09^{a}	0.1±0.01^{b}
SGR	3.75±0.07^{a}	2.89±0.07^{b}	3.9±0.13^{a}	3.1±0.13^{b}
Initial length (cm)	4.84±0.18	4.83±0.18	4.82±0.1	4.83±0.13
Final length (cm)	7.61±0.45^{a}	6.86±0.35^{b}	7.69±0.49^{a}	6.97±0.43^{b}
Daily length gain (mm)	0.79±0.02^{a}	0.58±0.02^{b}	0.82±0.03^{a}	0.61±0.03^{b}
Initial condition factor	1.54±0.11	1.55±0.12	1.55±0.12	1.54±0.08
Final condition factor	1.47±0.11^{a}	1.49±0.12^{ab}	1.49±0.09^{ab}	1.52±0.1^{b}
FCR	0.97±0.02^{a}	1.28±0.04^{b}	1.03±0.06^{a}	1.03±0.06^{a}

Means with different superscripts significantly differ at $p<0.05$. There were no statistical differences in intra-group variability (ANOVA).

Sander lucioperca had significantly higher weight gains (361% and 400%, for the group grown separately and that grown together) than the hybrids (267% and 283%, likewise) during the 5-week experiment. The SGR values of the *S. lucioperca* and the FCR of 0.97 g/g are similar to studies carried out with fish of a similar size (Hilge, 1990; Demska-Zakęś and Zakęś, 1997; Molnár et al., 2004).

When both kinds of juveniles were raised separately, they became accustomed to handling and the daily routine (siphoning, cleaning the walls) in a short time, but the hybrids poorly tolerated disturbance. The hybrids in the mixed group were not as stressed as the hybrids raised separately. On the other hand, it was much easier to train the hybrids to accept artificial food than the *S. lucioperca*. In our case, the survival rate of the hybrids was 90-95%, compared to training losses in *S. lucioperca* of 31-88% (Zakęś and Demska-Zakęś, 1996; Zakęś, 1997, 1999; Molnár et al., 2004) and survival of 100% in *S. volgensis* weaned to dry feed (Bercsényi et al., 2001). Thus, in intensive pike-perch production, the slower growth of the hybrids may be compensated by their more successful artificial food training.

Further investigations are needed to examine quantity traits of the hybrids, compare the hybrid with *S. volgensis*, and investigate the possibility of back-cross hybridization.

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